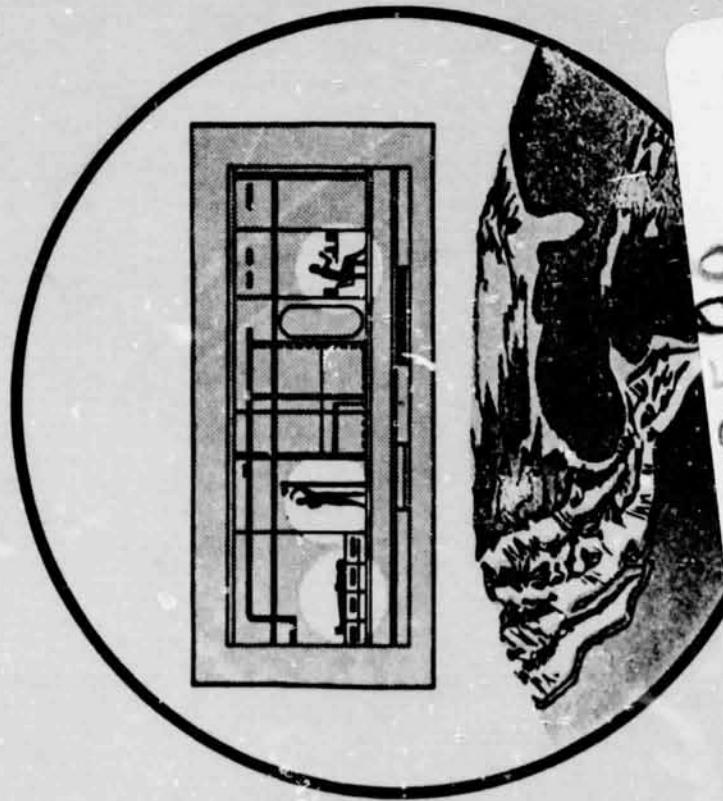


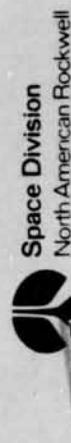
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SPACE STATION PROGRAM



EUROPEAN SPACE STATION SYMPOSIUM

JUNE 3 THRU 5, 1970



Space Division
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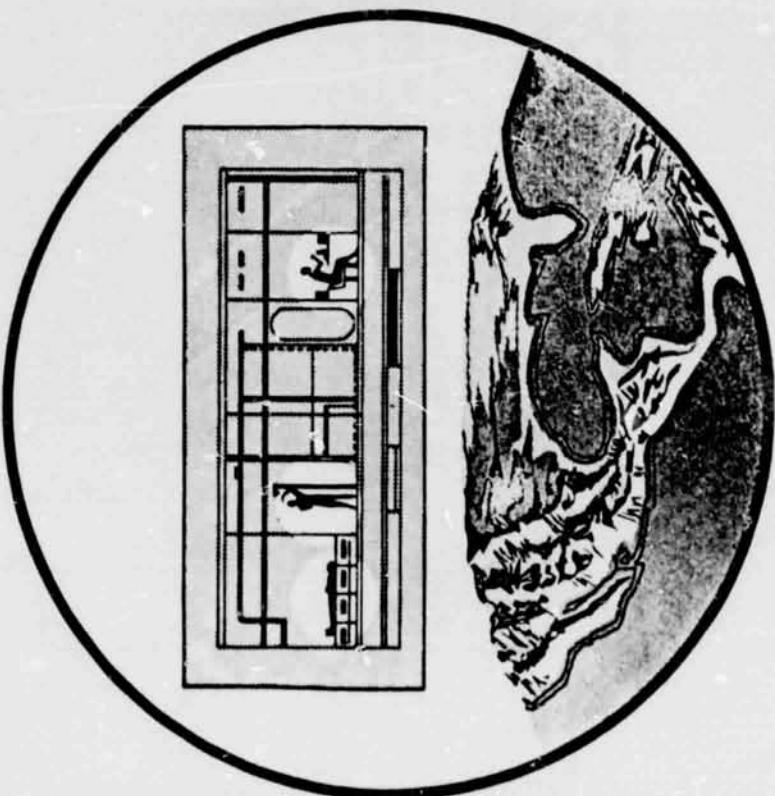
SPACE STATION PROGRAM

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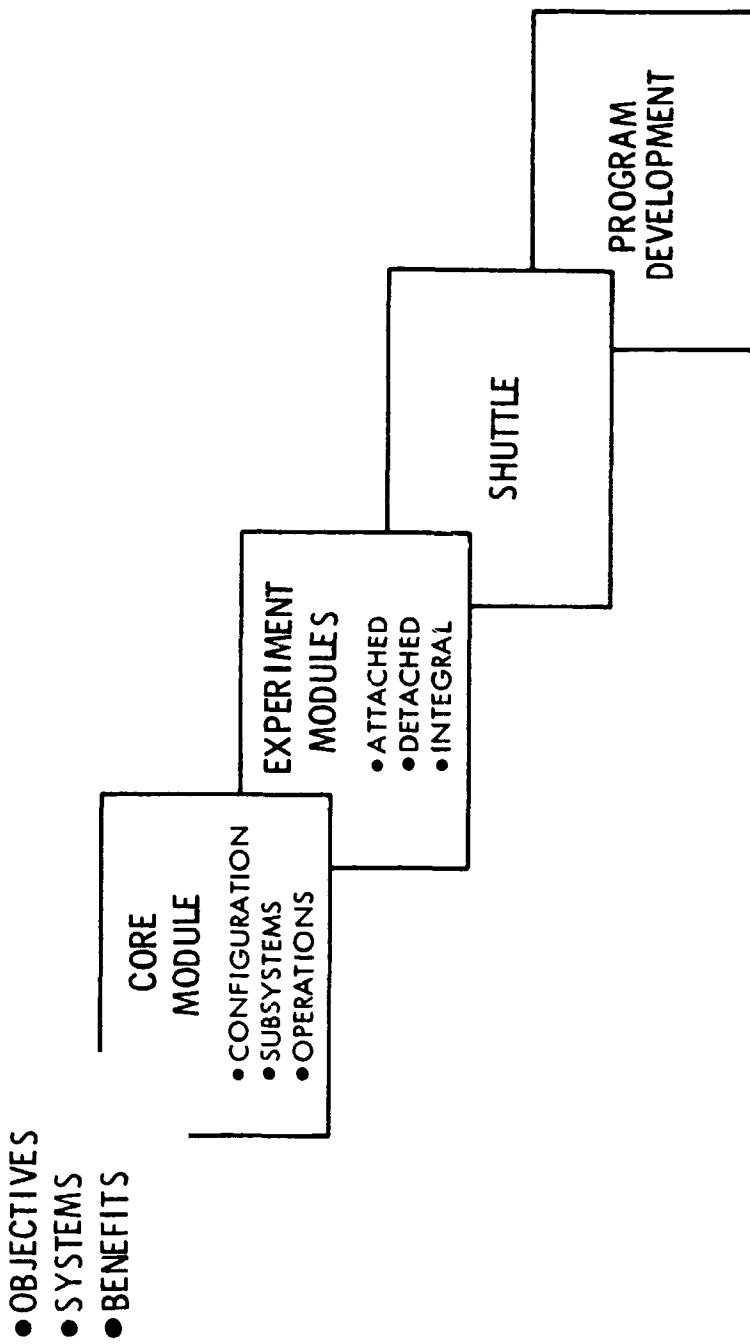
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This presentation is a brief summary of some of the main features of the Space Station program as it is currently evolving from the Phase-B Program Definition Study. It begins with an overall discussion of space station objectives, the systems which make up the overall program, and the benefits that are accruing from the Space Station program. This is followed first by a brief outline of the core module configurations, subsystems, and operations and second by a brief discussion of experiment modules including those which are attached to the Space Station, detached from the Space Station but operating in conjunction with the Space Station, and those experiments that will be undertaken within the core module. Next, a brief summary is given of the earth-to-orbit shuttle system, which is a vital element in providing low cost and convenient transport of personnel and materials to an orbital station. The presentation concludes with a few remarks on the program development aspects of the Space Station program.

PRESERVATION OUTLINE



- OBJECTIVES
- SYSTEMS
- BENEFITS

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The many objectives of the Space Station can be summarized into two. First, it is desired that an orbital facility with an operating life of up to ten years and a capability of supporting twelve crew members for periods of up to six months in orbit be provided. One of the main factors necessitating the long operating life requirement is basic economics — i.e., once a Space Station is placed in orbit, it is desirable to obtain the benefits that will accrue over a long period of time.

The Space Station program will incorporate a high degree of flexibility together with a capability to accommodate the conduct of a multidisciplinary experiments-and-applications program in low earth orbit; the accomplishment of this program is to a large extent the reason-for-being for the Space Station. Flexibility is of the utmost importance since at this time in the evolution of our thinking and planning on this program, it is not possible to define precisely the activities that will be accomplished. Furthermore, even following initial launch of the Space Station, the very nature of the activities to be accomplished will change as the program evolves, and flexibility will allow the Station to be responsive to these changing needs.

SPACE STATION OBJECTIVES

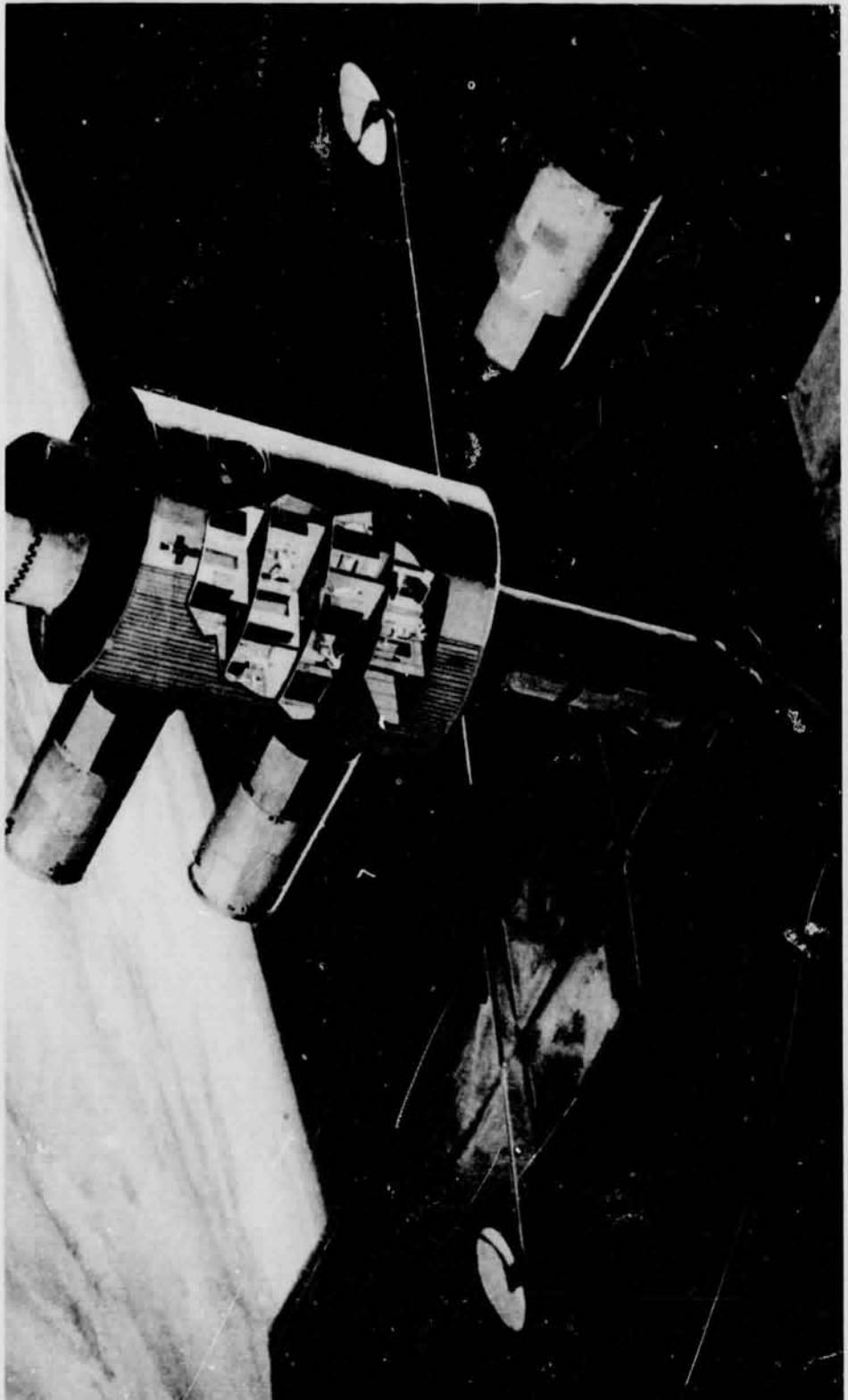
PROVIDE A SELF CONTAINED FACILITY WITH A MINIMUM OPERATING LIFE
OF TEN YEARS, CAPABLE OF SUPPORTING A CREW OF TWELVE FOR EXTENDED
PERIODS

INCORPORATE A HIGH DEGREE OF FLEXIBILITY AND CAPABILITY TO
ACCOMMODATE THE CONDUCT OF A MULTI-DISCIPLINARY EXPERIMENTS
AND APPLICATIONS PROGRAM IN LOW EARTH ORBIT



This chart depicts the 12-man Space Station as currently conceived out of the on-going Phase-B Space Station Program Definition activities. The concept shows four decks in the core module, two attached experiment modules, and a detached experiment module floating in the immediate proximity of the Station. The solar arrays represent just one possible means of generating the 25 kilowatts of power required by the Space Station. The core module is 33 feet in diameter and approximately 50 feet in length and is launched by the INT-21 launch vehicle (S-IC/S-II) from one of the Saturn-V launch pads already in existence at Kennedy Space Flight Center. The Space Station is designed to operate in a low earth orbit at an altitude of 200 to 300 nautical miles and a nominal inclination of 55 degrees. Current planning indicates that this Space Station could be launched late in Calendar Year 1977 and could operate in earth orbit for several years into the 1980's.

SPACE STATION CONCEPT



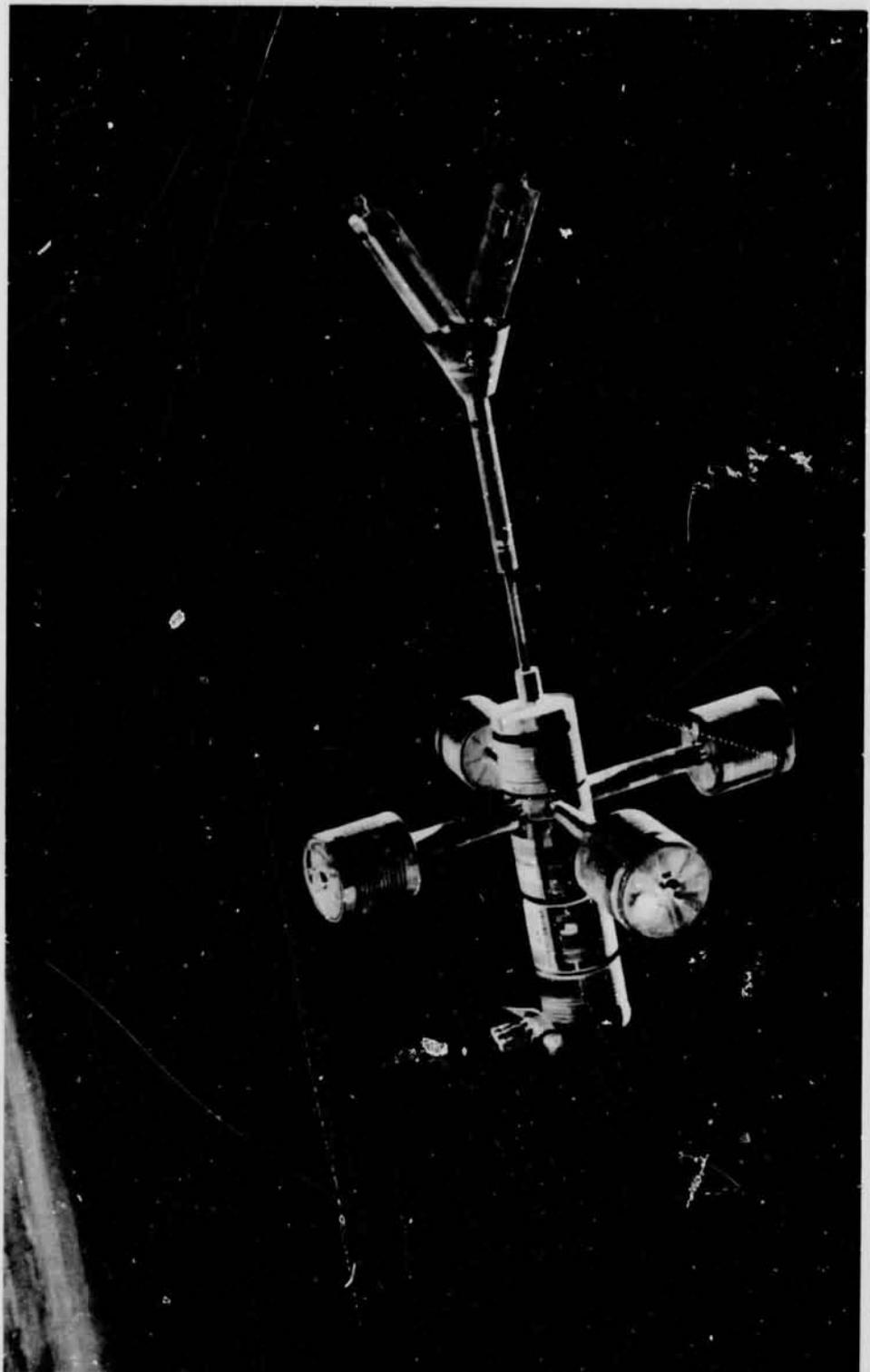
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This chart shows an artist's concept of the 50-man Space Base. The crew modules used in the Space Base can be evolved from the 12-man Space Station module. The concept shows the two nuclear reactors which provide electrical power of up to 100 kilowatts, joined to the zero-g hub. The Space Base, which operates in low earth orbit some time during the decade of the 1980's, is a multipurpose research and development facility to which scientists and other users can be transported by the Shuttle and which will support these people while they are undertaking their particular planned activities in orbit.

SPACE BASE CONCEPT




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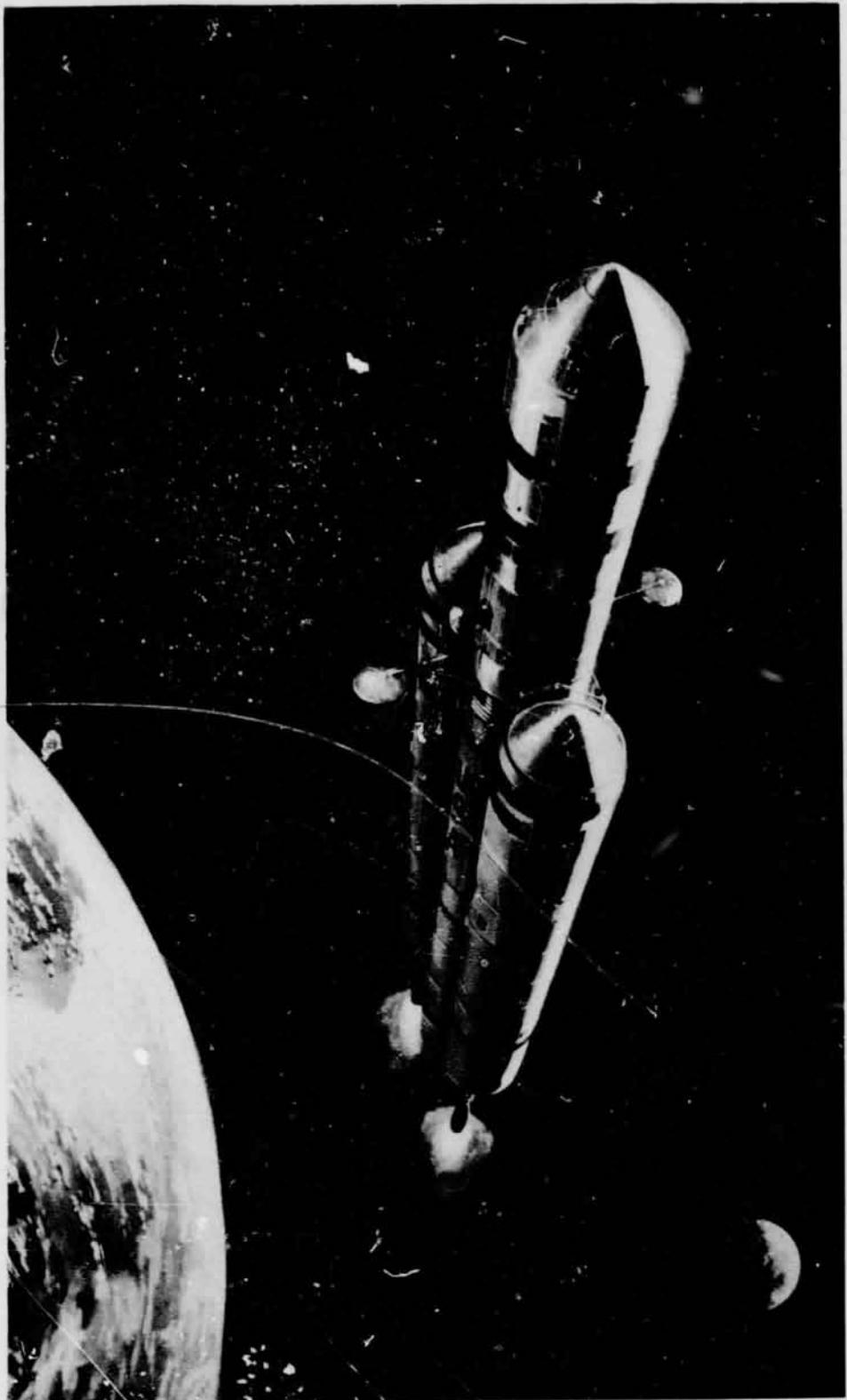


The Phase-B Space Station Program Definition activities have also considered the evolution of the Space Station module into the manned planetary mission module. Shown here is an artist's concept of the manned planetary vehicle as it leaves the earth on its transplanetary mission in the mid-to-the late-1980's.

Nuclear propulsion using Nerva-I type engines provides the primary propulsion for this deep space mission. The primary mission under consideration is one which will accomplish a Mars landing using the Mars orbital rendezvous technique and a swing by Venus on the return leg to earth. Depending on the mission opportunity, the total mission duration is between one and two years. The 12-man earth orbital Space Station has a large number of the features required by a planetary mission module; and it is desirable, where possible, to shape the Space Station program in such a way that it represents the maximum step along the road to this possible mission of the future, while at the same time it does not compromise the station for its primary earth-orbital mission objectives.



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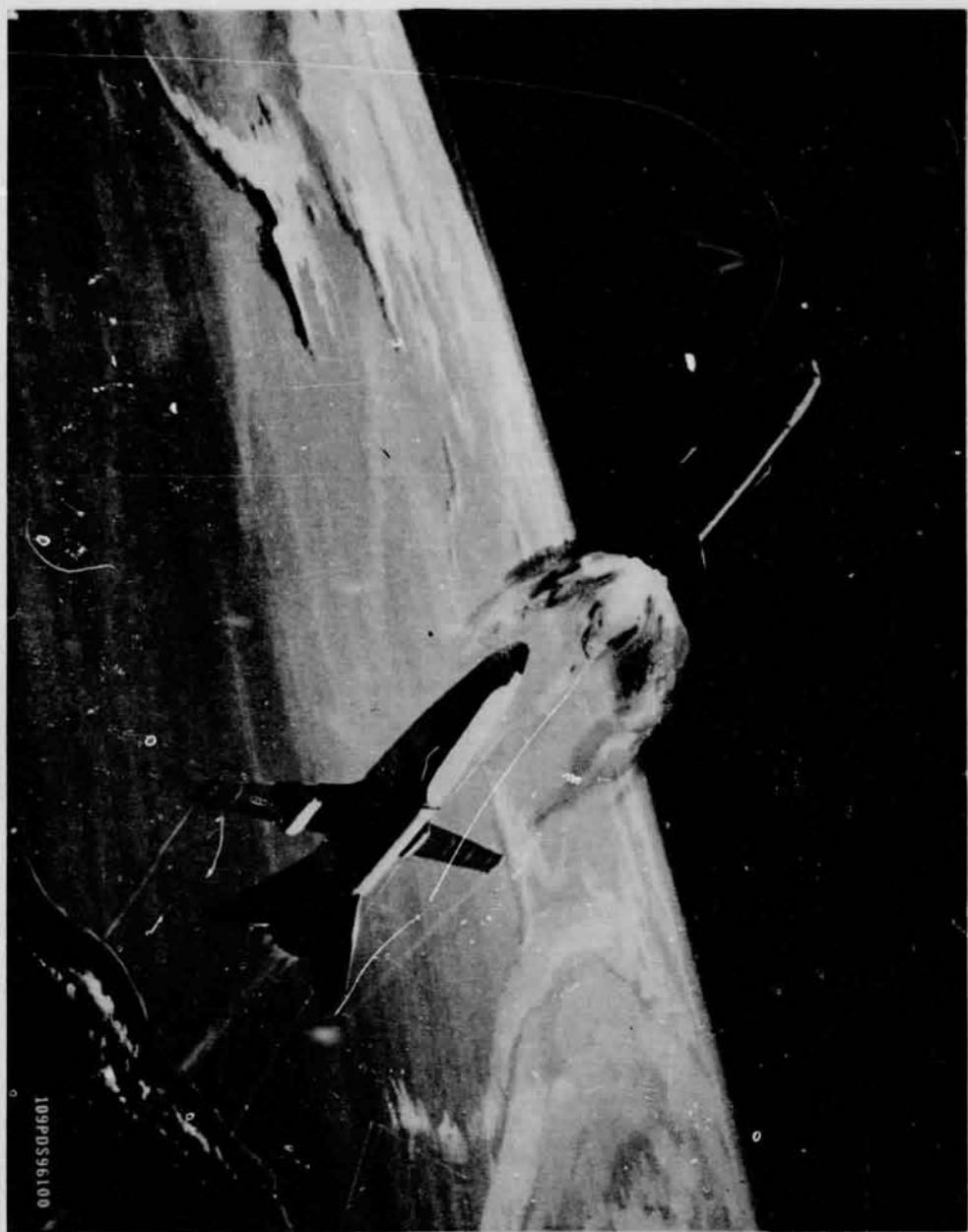
PLANETARY SPACE VEHICLE CONCEPT

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During the late 50's and the decade of the 60's, the limitations of technology required that the transport of man and other payloads to earth orbit be accomplished by a multistage expendable launch vehicle. As the level of activities in earth orbit increases and as the number of crew and the amount of cargo required to be transported to earth-orbit increases, the desire for a much lower cost and more convenient means of transporting personnel and material to orbit is obviously required. The two-stage, all-reusable shuttle depicted here is one means of accomplishing this. Whereas the development of a system of this type requires the dedication of considerable resources over several years, the tremendous increase in convenience and economy represents the essential breakthrough necessary for a viable space program.



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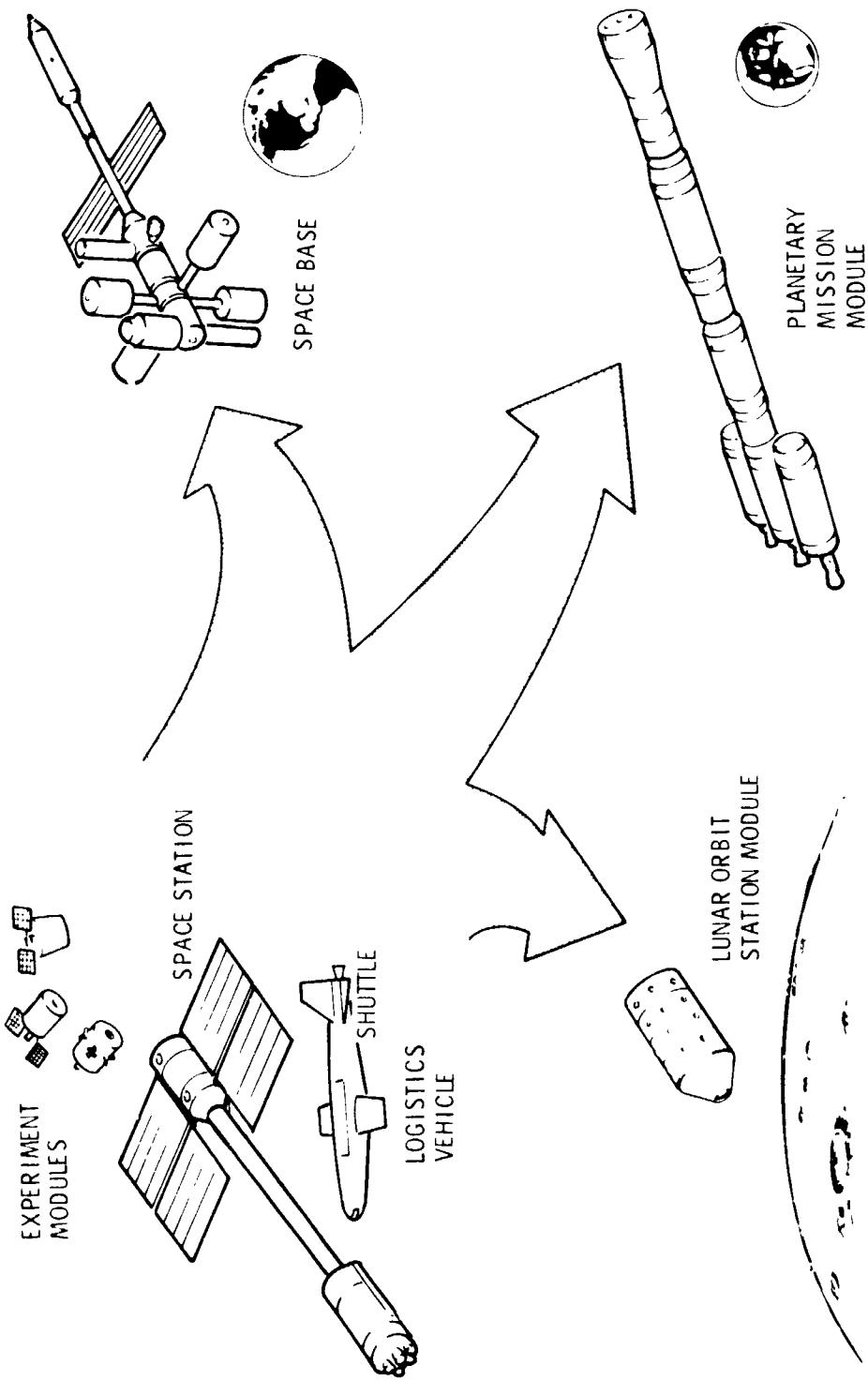


SPACE SHUTTLE

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In summary of the main points made by the last four charts, it is foreseen that the 12-man Space Station module will be operated initially in low-earth orbit. Another Space Station module can then be launched into other orbits, perhaps even synchronous or lunar orbit; and it represents the basic "building block" module for the Space Base program and a major step along the road to a possible manned planetary mission. Hence, the Space Station module once developed represents a very versatile and flexible module which has the ability of supporting men in the space environment to accomplish many possible missions over a period spanning two or more decades. The earth-to-orbit shuttle represents the major breakthrough in convenient, economical transportation from the surface of the earth into low earth orbit which will allow the full exploitation of the Space Station module in all its mission applications.

SPACE STATION PROGRAM EVOLUTION



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Before proceeding with the discussion of some of the details of the Space Station core module, the experiment modules, and the Shuttle, the following summary of the major contributions made by the Space Station program is given.

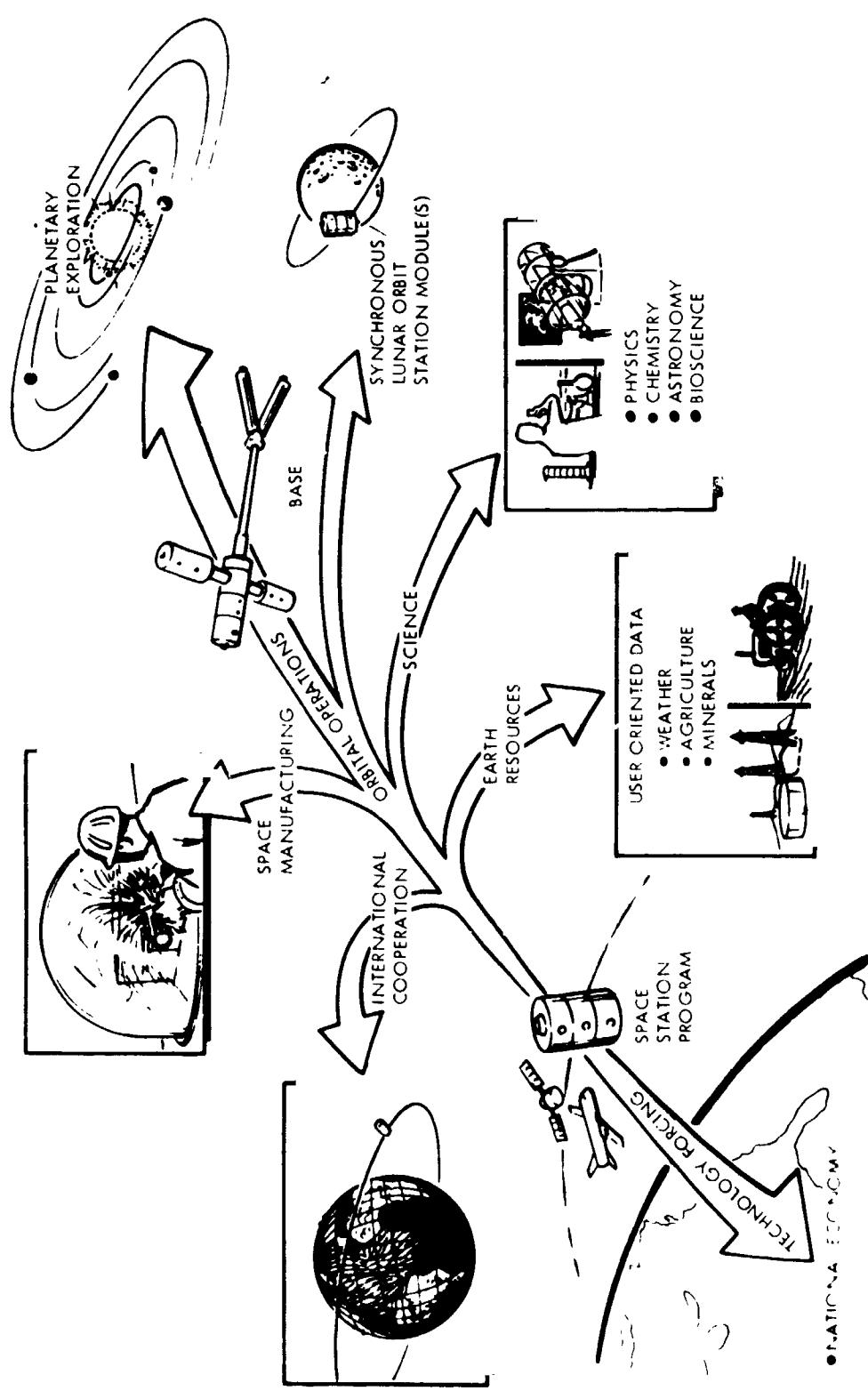
In addition to being the basic "building block" module for various earth-orbital and lunar-orbital missions to the Space Base and manned planetary exploration, the Space Station will make very major contributions in the late 70's and the early 80's in areas such as earth resources, science, space manufacturing, and international cooperation; it will also be a forcing function for technology with the resulting benefit which will accrue to the nations that participate in its development. The unique features offered by earth-orbital space, i.e., zero gravity, above the atmosphere and within a limitless vacuum, make an earth-orbital Space Station a very unique scientific research laboratory. Research in the areas of high energy particle physics, astronomy outside the atmosphere which blankets the earth, and bioscience in the zero gravity environment are but a few of the very exciting possible fields of scientific research.

The use of the Space Station both to develop the sensors and the technology for remote sensing from space of the resources of the earth will be one of the major contributions of such a program. In certain cases, earth-resources remote sensing systems once developed may be flown unmanned, but in other instances, the Station can continue in very useful programs of generating operational-type information on the distribution of the resources of the earth. User oriented data such as weather information, agricultural conditions, and the location of minerals on a world-wide basis represent but a few of the areas of activity that will be pursued.

With the introduction of a low-cost transportation system to earth orbit, the unique characteristics of space (zero gravity, high vacuum, and extremes of temperature) can be exploited to undertake certain unique manufacturing processes either in the category of those that perhaps cannot even be accomplished on the surface of the earth or, if accomplished on the earth, are only accomplished at such a high cost that transportation of man and materials into earth orbit can be economically justified. The Space Station will represent an important means of developing these techniques and processes which might subsequently be exploited in the manned space programs of the 1980's.

The considerable potential of an earth-orbital Space Station program for making major contributions to international cooperation are very clear. The possible scope of international participation ranges from principal investigator type participation through development of experiments or experiment modules or even perhaps certain system elements. The consideration of the benefit to international cooperation has been a theme from the very initiation of the thinking on the Space Station program.

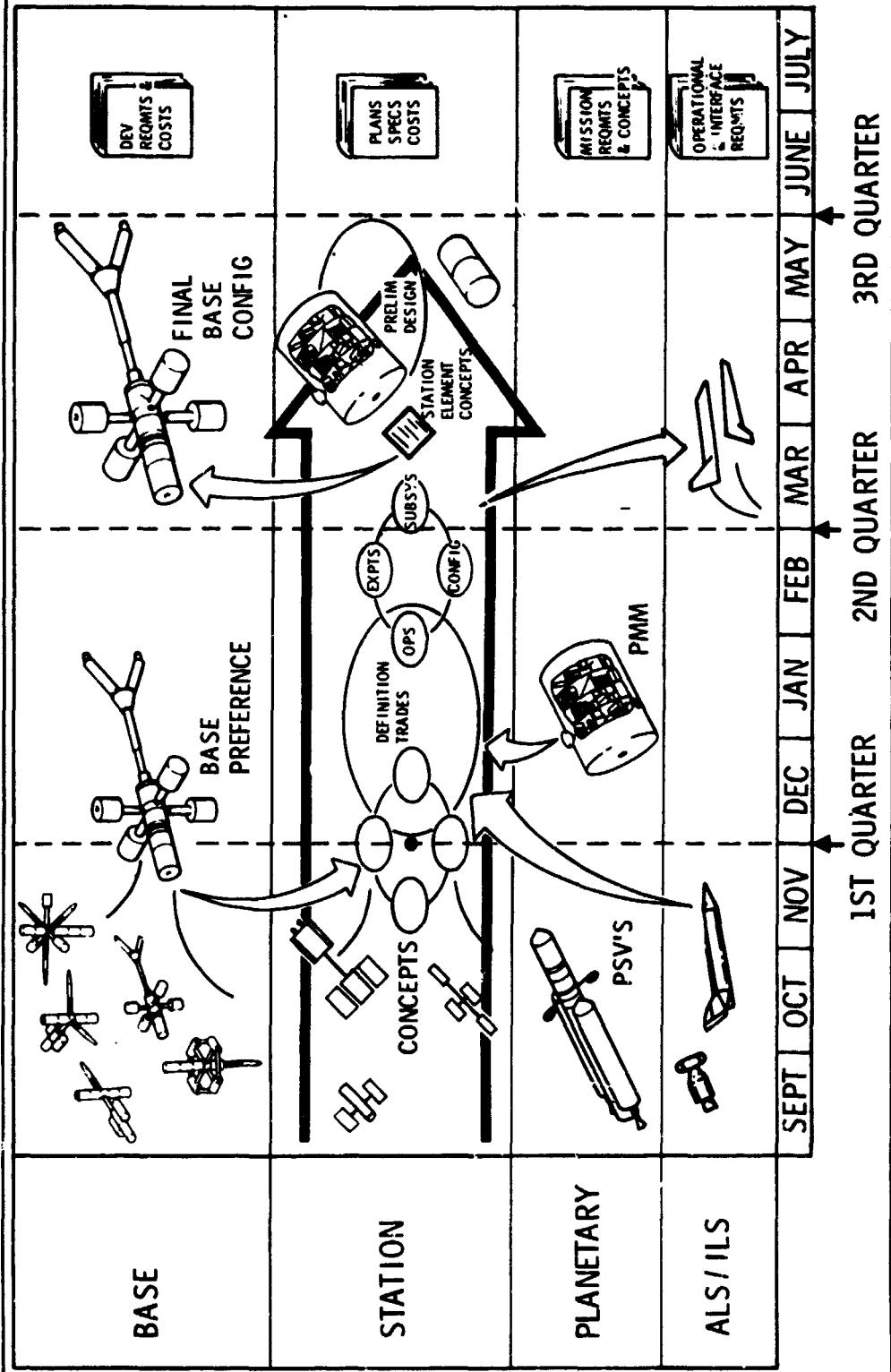
SPACE STATION PROGRAM CONTRIBUTIONS/EVOLUTION



The overall study approach to the Phase-B Space Station definition activity started in September of 1969 and will continue through July 31, 1970. The products from this activity include the preliminary design of the Space Station core module and the earth-resources attached experiment module and include the program plans and specifications for the subsequent detail design, development, and operations of the core module and the earth-resources module. Approximately 60 percent of the activity of the Phase-B study is directed toward these products.

The first three months of the Space Station activity include the conceptual definition (Phase A) of the Space Base as well as the conceptual definition of the planetary space vehicle with particular emphasis on the manned planetary mission module. The Space Base and the planetary mission module once defined were then iterated with the evolving Space Station core module configuration in order to optimize the programmatic evolution from Station through Base to the planetary mission module with maximum continuity. The logistics system, with particular emphasis on the Shuttle system, was considered in order to assure that the Space Station and the Space Base were compatible with the Shuttle and to define those requirements that these systems imposed on the Space Shuttle.

STUDY APPROACH





The development of the program elements which make up the Space Station program (i.e., core module and experiment modules) does not offer any necessity for major breakthroughs in the state of the art. The major new development challenge represented by this program is that of developing systems which will get the 10-year total life requirement which clearly represents a major step beyond the mission duration requirements necessary to accomplish previous manned space missions such as Mercury, Gemini, and Apollo. Even the Skylab program currently in development has life requirements which fall far short of those on the Space Station program. It is perhaps interesting that while long life represents the major new technical challenge of the Space Station program, it represents also the major benefit once the challenge has been addressed and overcome. The issue of long life affects all aspects of the design, the testing program, and the operations once the Space Station is in orbit. Considerations such as inflight maintainability, the development of a new generation of long life systems, and the implementation of onboard checkout, as well as considerations of crew workload and crew skills, are all new with the advent of the Space Station program.

LONG LIFE MAJOR NEW TECHNICAL CHALLENGE



DESIGN

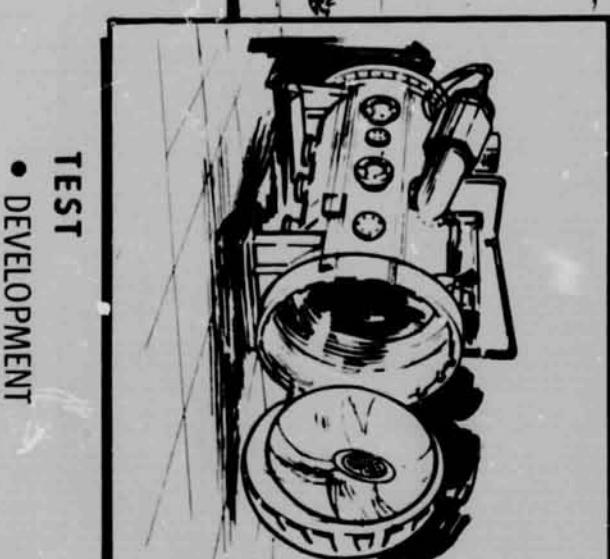
- LIFE CHARACTERISTICS
- MARGINS
- REDUNDANCY / ALTERNATE MODES
- MAINTAINABILITY

TEST

- DEVELOPMENT
- QUALIFICATION

OPERATIONS

- WORKLOAD
- SKILLS
- ON-BOARD CHECKOUT



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Looking for a moment at those component-level failure modes which must be addressed and much more clearly understood, it can be seen that there is considerable need for development of hardware which has lower performance drift characteristics and for significant breakthroughs in corrosion. Also we must consider leakage, vacuum effects, and degrading effects of radiation and of the extremes of temperature cycling for the long durations under study. An understanding of all these basic degrading phenomena at the assembly and the component level represents a considerable engineering development challenge. Manned systems technology clearly has much to learn in this regard from currently operational or currently planned unmanned space programs and other non-space programs. The basic development activities to understand and counter these failure or wear-out mechanisms must be undertaken.

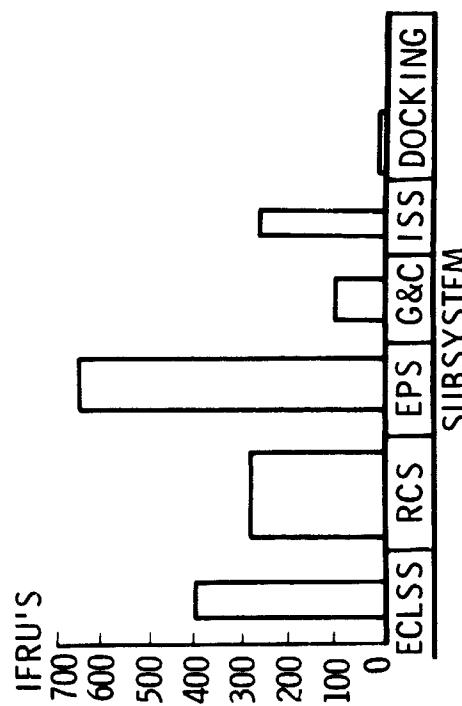
TIME RELATED FAILURE MODES

FAILURE MODE	REQUIRED GUIDELINES
PERFORMANCE DRIFT	DE-RATING/FACTOR OF SAFETY
WEAR-OUT	FRiction, LUBRICATION
CORROSION	CHEMICAL, ELECTROLYSIS
CONTAMINATION	CUMULATIVE EFFECTS, CORROSION, WEAR-OUT
LEAKAGE	TOLERANCE, PERFORMANCE, DEGRADATION
VACUUM EFFECTS	CHANGES IN MATERIAL & MECHANICAL PROPERTIES
RADIATION	CHANGES IN MATERIAL & MECHANICAL PROPERTIES
TEMPERATURE	EFFECTS OF HIGH, LOW & CYCLING TEMPERATURE

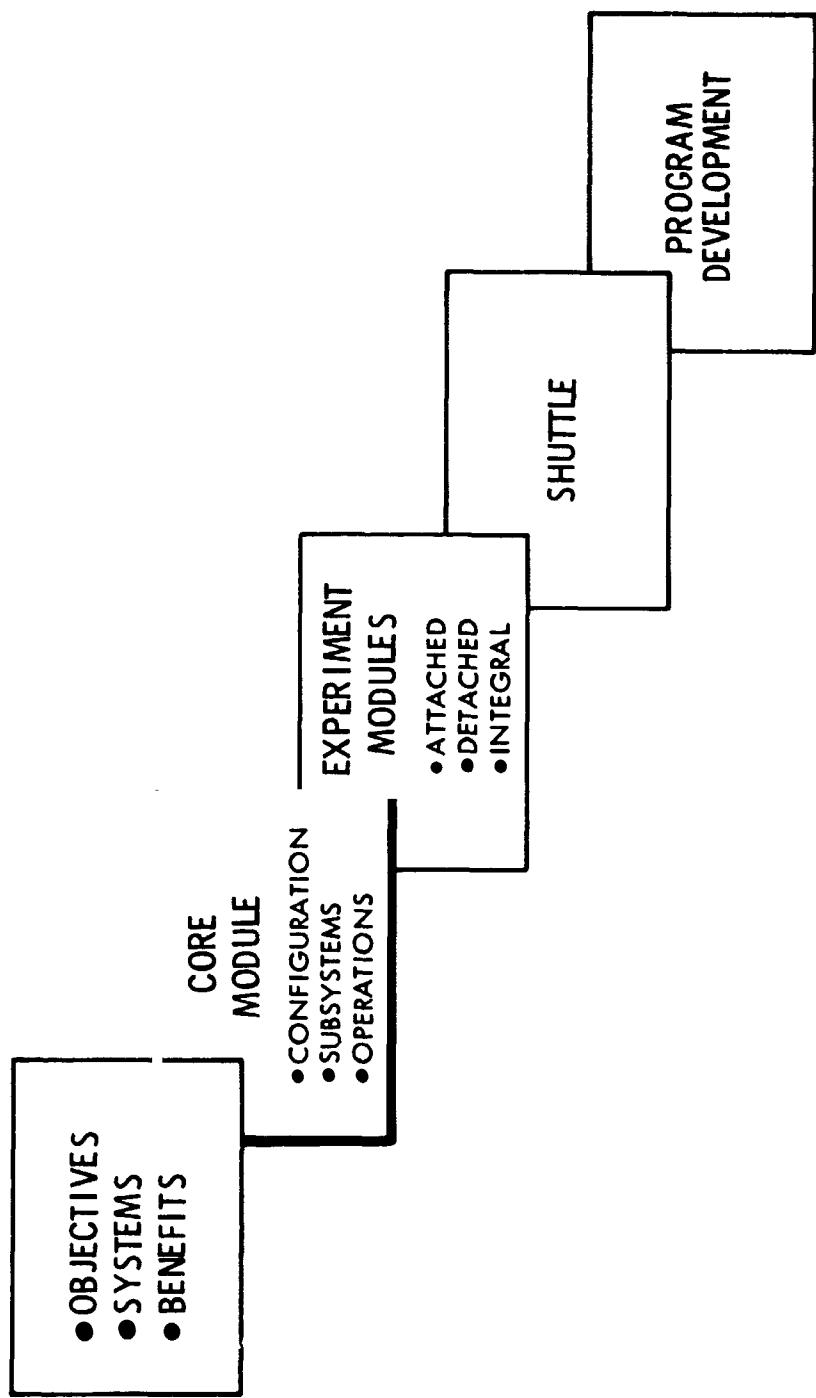
Inflight maintainability must consider such things as the limitation on crew size and crew skills and the need to minimize the number of replacements in order to not impose an excessive burden on the crew which would detract from the experiments/applications program which is being accomplished. It appears that there are approximately 2,000 inflight replaceable units (IFRU) with a large number of these occurring in the electrical-power and the environmental-control life support systems. The use of commonality, standard replacement techniques, and an IFRU with the appropriate life must all be considered in relation to each other. The bar chart in the lower left hand corner indicates the estimated number of IFRU's in each of the major subsystems. The width of the bar is indicative of the estimated average IFRU replacement time which varies from 0.7 hours for a typical electronic system with solid state components to 3.5 hours for the reaction control system (RCS) which involves replacement of fluid/mechanical components. Due to extensive commonality of parts in the electrical power subsystem (EPS), it is estimated that the total number of 646 IFRU's contain only 12 unique or different types. The curve in the lower right hand corner depicts the estimate of 100 to 135 man-hours per month for scheduled maintenance. Unscheduled maintenance resulting from failures or accidents would require additional crew time. The peaks at three-year intervals account for large replacements in the reaction control subsystem and solar arrays.

MAINTAINABILITY FACTORS

LIMITING FACTORS	COMPENSATING FACTORS
• LARGE NUMBER OF IFRU'S (APPROX 2000)	• LONG LIFE IFRU DESIGN
• HIGH NUMBER OF REPLACEMENTS DUE TO TIME RELATED FAILURES	• MINIMUM TOOLS • COMMONALITY • STANDARD TECHNIQUES
• COMPLEX TOOLS - PROCEDURES	
• LIMITED CREW & SKILLS AVAILABLE	



PRESNTATION OUTLINE

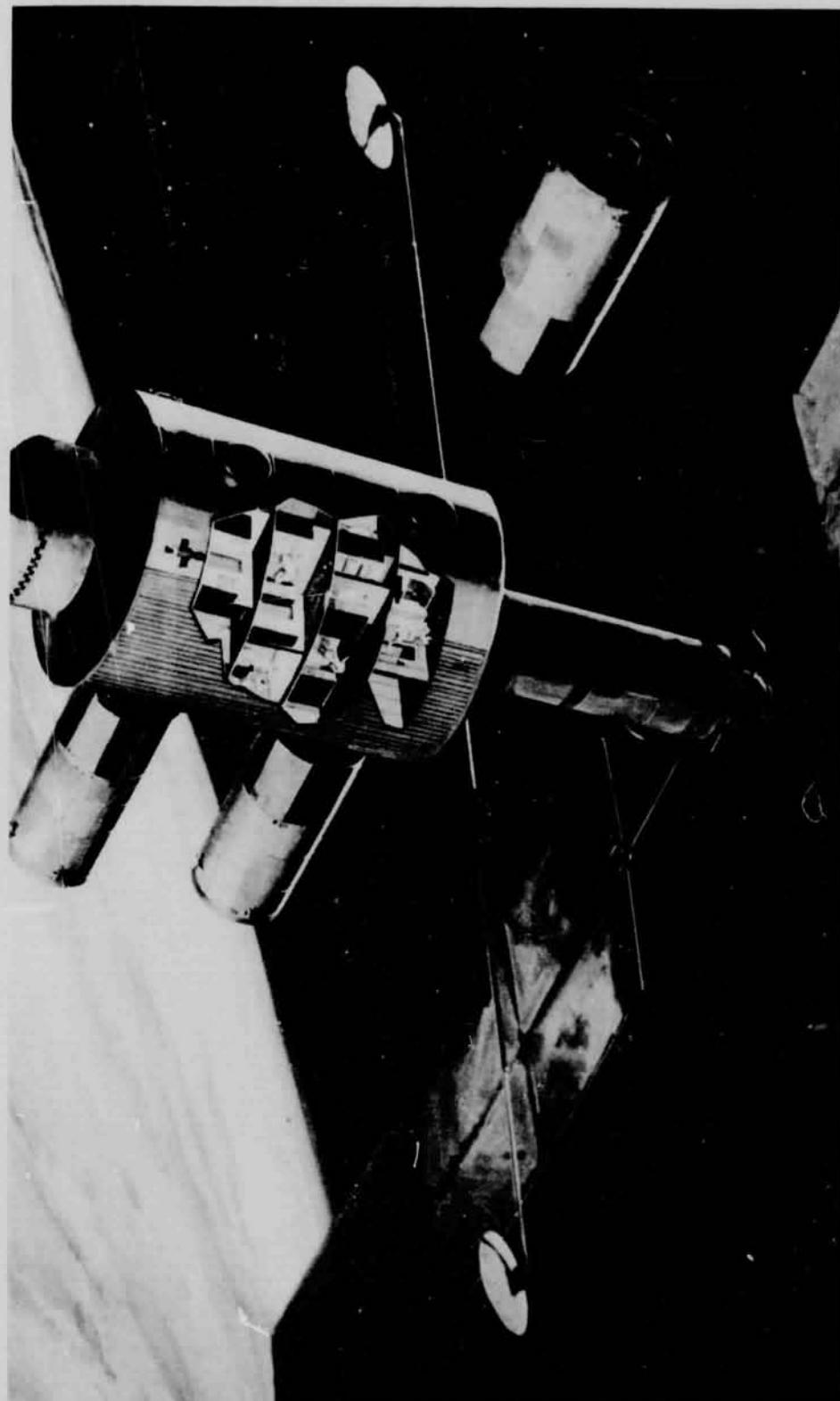


PROBLEMS DATA ANALYSIS

This chart depicts some of the major features of the Space Station core module. It shows four decks with a toroidal area at each end of the core module used primarily for storage of various types. There are two pressure volumes and six docking ports used for docking either the shuttle vehicle, the attached experiment modules, or the detached experiment modules while they are attached to the core module for servicing and maintenance.



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SPACE STATION CONCEPT

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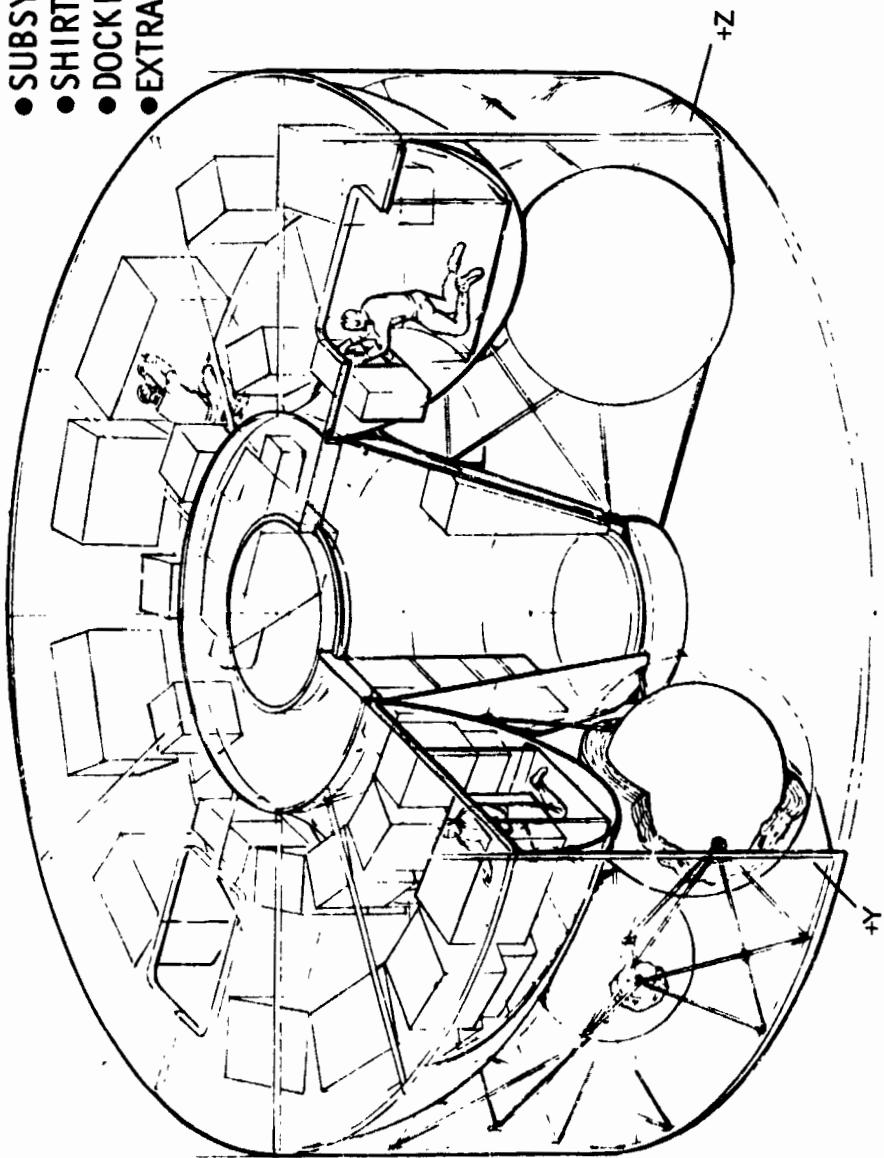


A greater detailed look at the lower torus area/tunnel in addition to the bulk storage tanks shows the large, extravehicular airlock with a docking port at the outer end. This area has a completely shirt-sleeve environment. A main aisleway is utilized in the torus to allow crewmen access to the equipment mounted on both sides of the aisleway. The aisleway and equipment are structurally supported from the Deck-1 bulkhead above, which forms the ceiling of the toroidal area. Two large 4- by 5-foot access openings in the Deck-1 bulkhead (toroidal ceiling) provide access to the toroidal area. The lower tunnel is also utilized as an extravehicular airlock with a docking port at one end and a pressure hatch at the other. Below the torus area are located the propellant tanks of the RCS.

SPACE STATION INTERNAL CONFIGURATION

LOWER TORUS / TUNNEL

- BULK STORAGE
- SUBSYSTEM EQUIPMENT
- SHIRT SLEEVE ENVIRONMENT
- DOCKING PORT
- EXTRA-VEHICULAR AIRLOCK

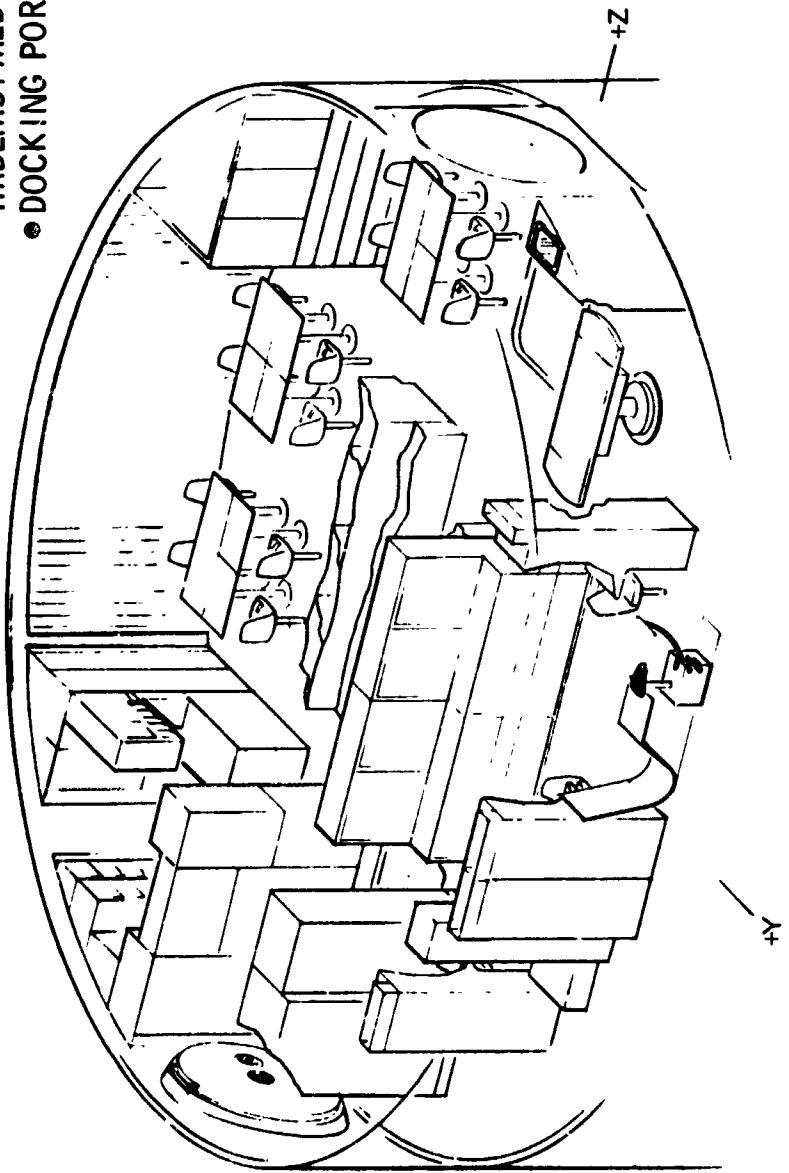


Deck 1 provides for the installation of the galley/dining and wardroom area, as well as the IMBLMS and medical area. Two docking ports are located on the Z axis, and a 5-foot-wide corridor joins both ports. To either side of the corridor are the two vertical utility distribution trunks with the main passage pressure hatch in the floor between them. The two torus access passageways are also located in this corridor. The radial utilities distribution trunks are located in the false ceiling mounted below the Deck-2 bulkhead. Two crewmen observation windows are also located in this deck.

SPACE STATION INTERNAL CONFIGURATION

DECK 1

- GALLEY / DINING
- WARDROOM
- IMBLMS / MEDICAL
- DOCKING PORTS (2)



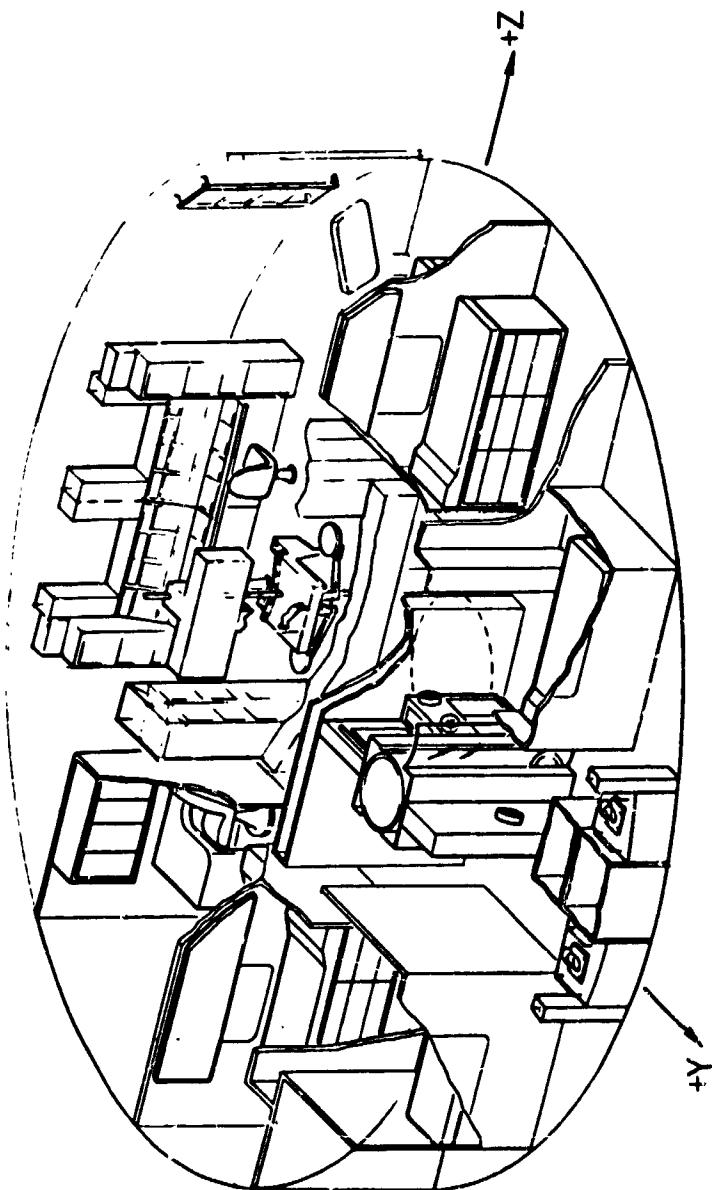
Deck 2 contains five staterooms for the crewmen and one larger stateroom for the commander. A personal hygiene area for the six crewmen is located on this deck. The primary control area is located directly opposite the commander's stateroom. A shorter, 5-foot-wide corridor is also located in the center of this deck. This corridor and the utilities distribution (vertical and radial) are similar to Deck 1 below and the decks above.

SPACE STATION

INTERNAL CONFIGURATION - DECK 2

- STATEROMS

- 5 CREW
- 1 COMMANDER
- PERSONAL HYGIENE
- PRIMARY CONTROL



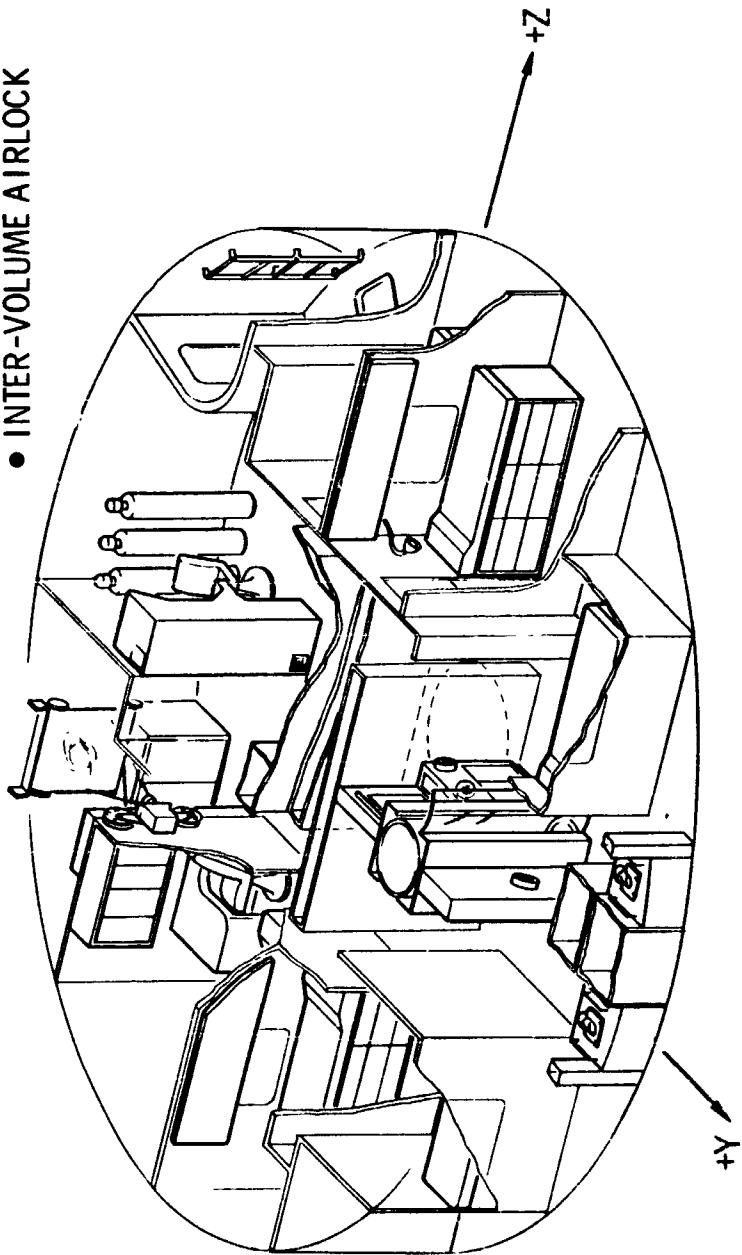


This deck is similar to Deck 2 except that the larger stateroom is for the chief investigator and the primary control center is replaced by the maintenance/repair area and the intervolume airlock.

SPACE STATION

INTERNAL CONFIGURATION - DECK 3

- STATEROOMS
- 5 CREW
- 1 CHIEF INVESTIGATOR
- PERSONAL HYGIENE
- MAINTENANCE/REPAIR
- INTER-VOLUME AIRLOCK



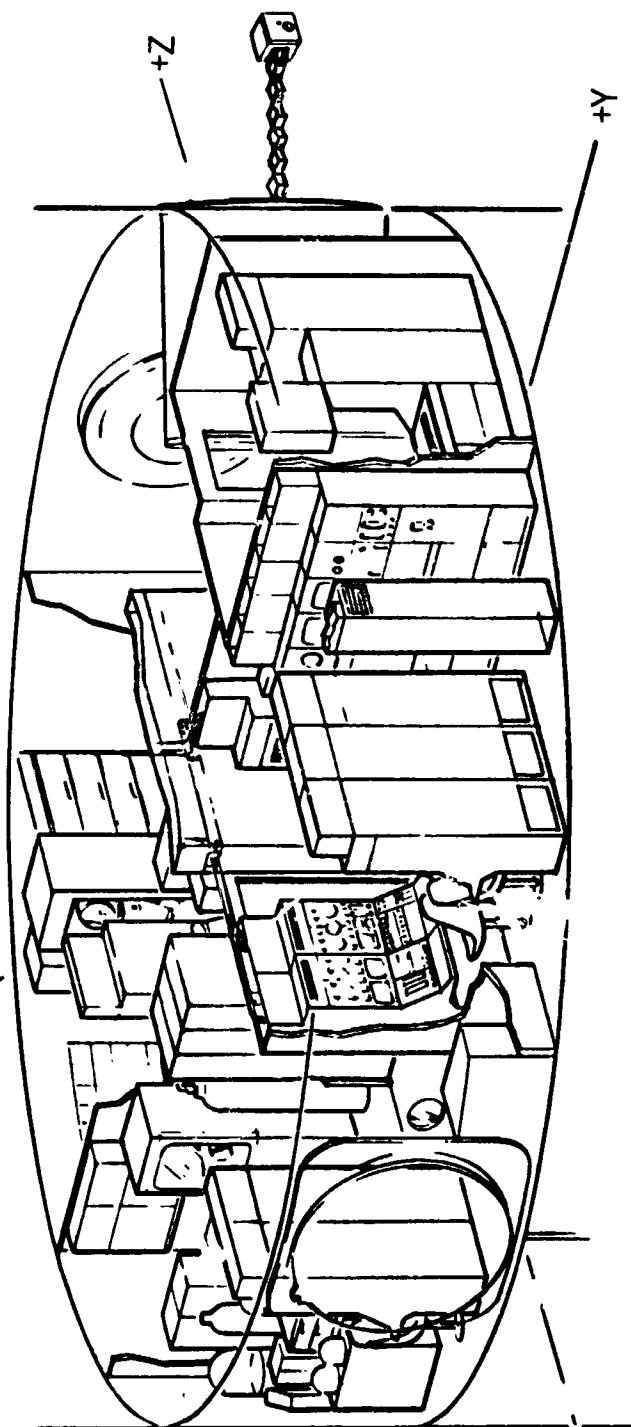


This deck contains the experiment installation, both the equipment installed as part of the initial unmanned launch and the equipment brought up by the Shuttle. The experiment control center provides the backup control center to the Station. The airlock laboratory, which is part of the Station onboard equipment, is also located on this deck. Two docking ports with the 5-foot corridor and vertical utilities distribution trunks are located on the +Z axis. The two large 4- by 5-foot openings in the ceiling provide access to the toroidal area above.

SPACE STATION

INTERNAL CONFIGURATION- DECK 4

- EXPERIMENT INSTALLATION
- BACKUP CONTROL
- AIRLOCK LABORATORY
- DOCKING PORTS (2)



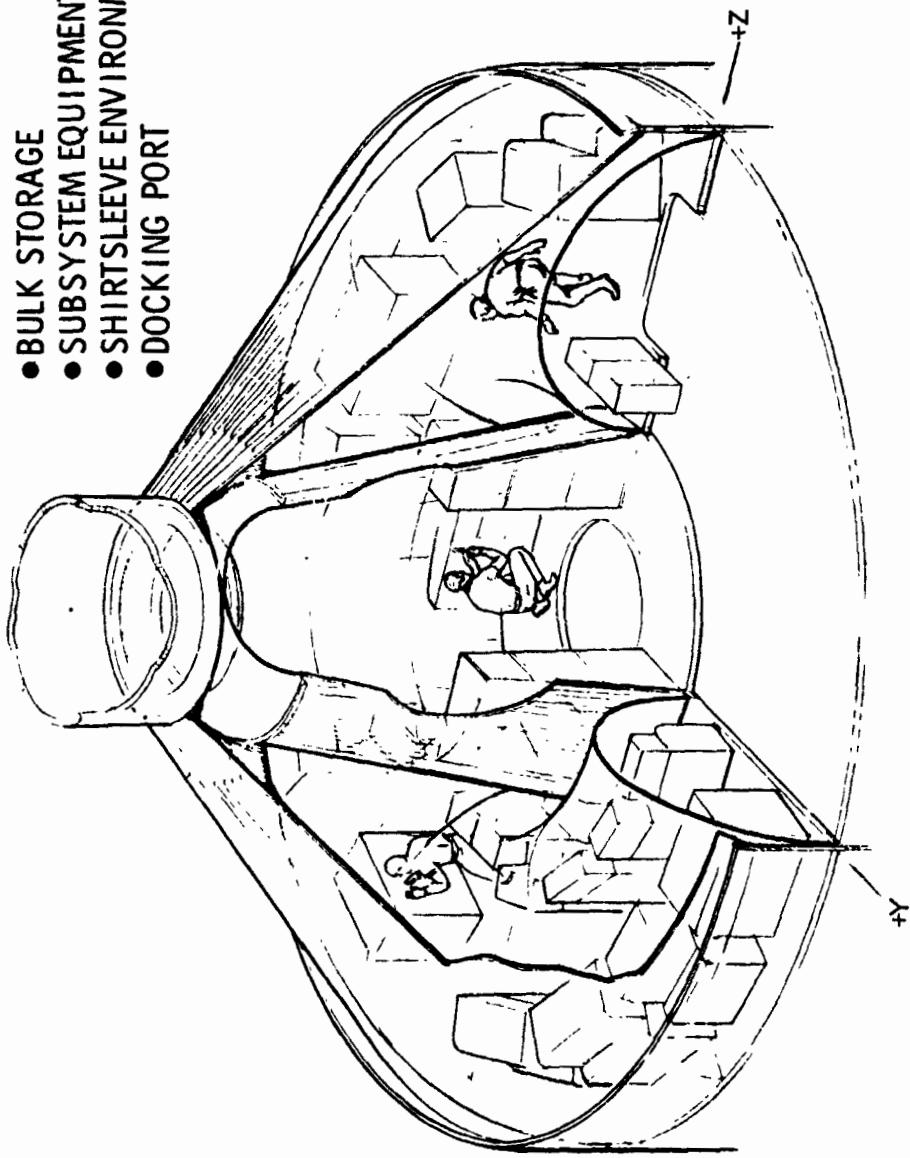


The equipment installation in the upper torus and tunnel area is similar to that previously described in the lower torus and tunnel area. Storage of bulk equipment and other selected subsystem equipment is in a complete shirt-sleeve environment. A main aisleway is utilized in the torus to allow crewmen access to the equipment mounted on both sides of the aisleway. The aisleway and the equipment are both structurally supported from Bulkhead 5, which is the floor of the torus area and the ceiling of the Deck 4 floor below. Two large 4- by 5-foot access openings in the floor provide access to the toroidal area. Access is provided directly into the upper tunnel from Deck 4 below. A single docking port is installed on the upper end of the tunnel.

SPACE STATION INTERNAL CONFIGURATION

UPPER TORUS/TUNNEL

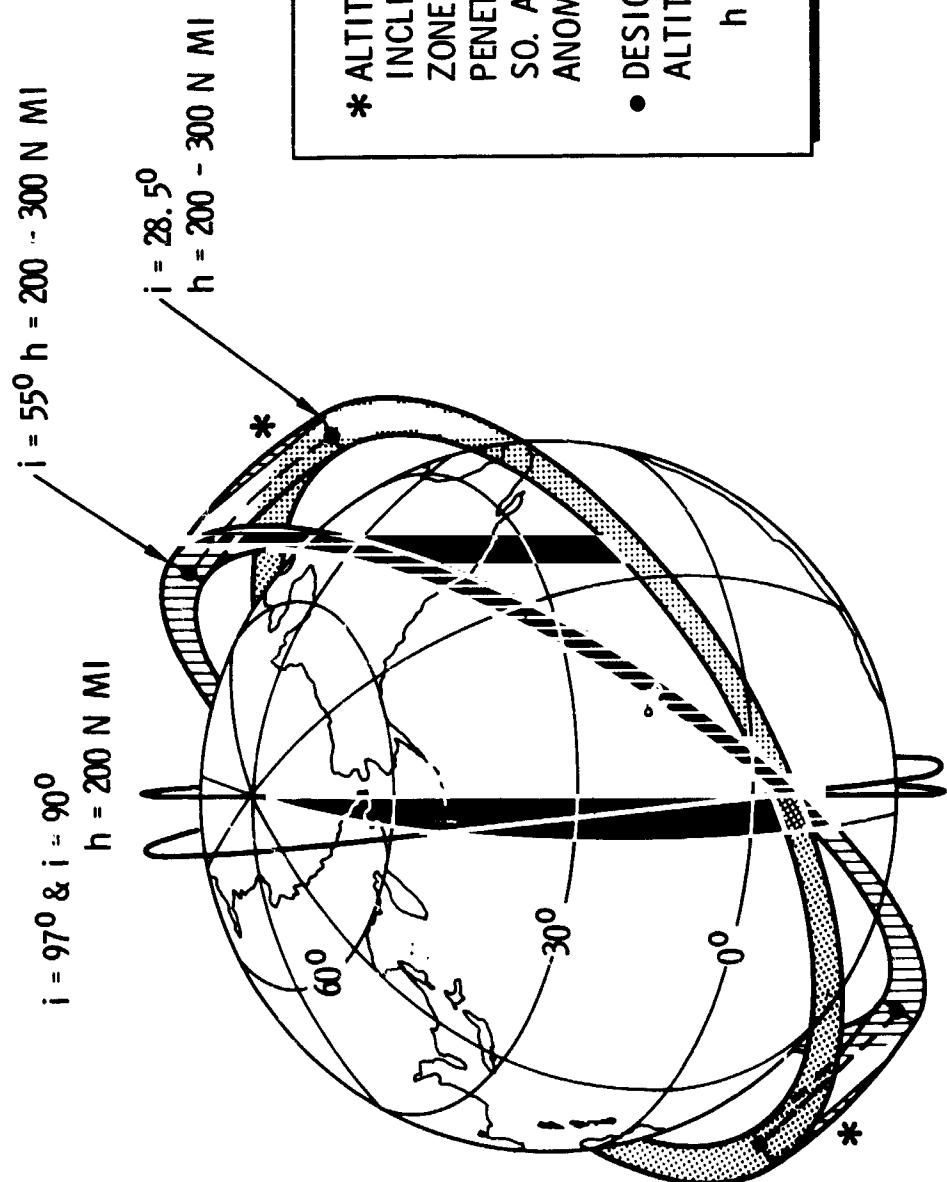
- BULK STORAGE
- SUBSYSTEM EQUIPMENT
- SHIRTSLEEVE ENVIRONMENT
- DOCKING PORT





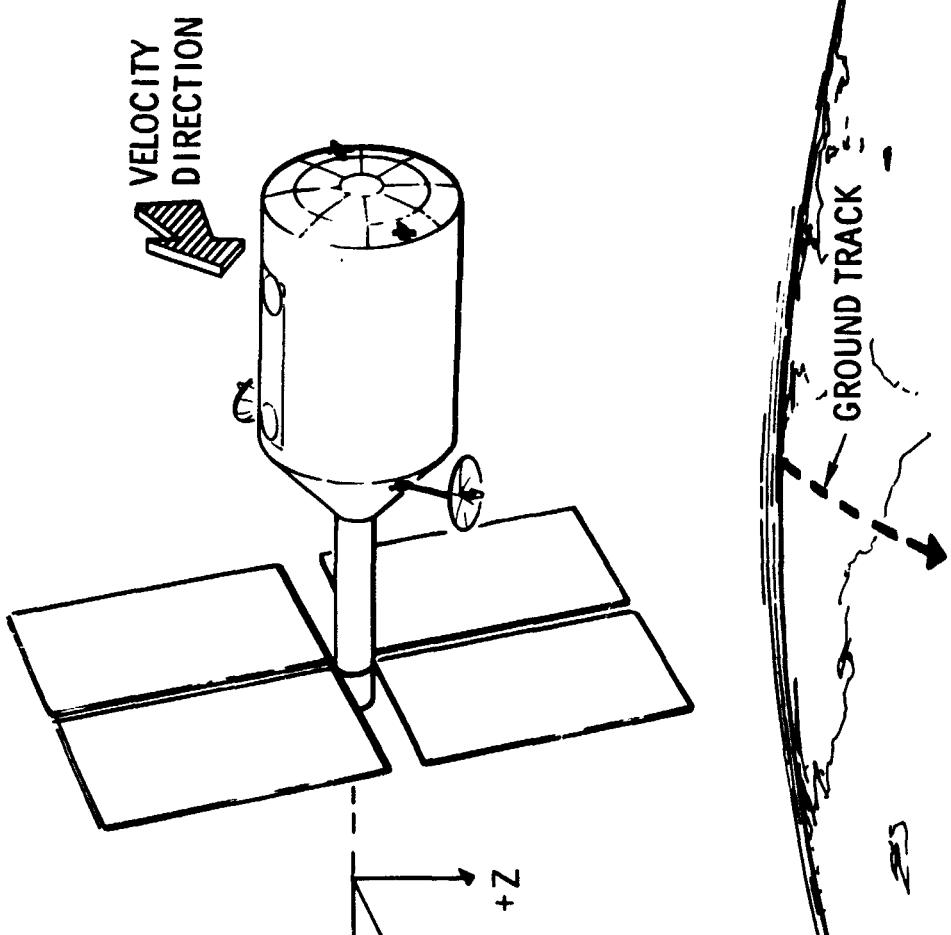
The Space Station is designed to operate in a flight box covering an altitude of 200 to 300 nautical miles and an inclination from 28.5 to 55 degrees. This altitude inclination zone penetrates the South Atlantic anomaly with its corresponding high radiation environment. Expendable provisions are being sized to a 240-nautical-mile, 55-degree-inclination design point. The Space Station is designed to operate satisfactorily (without artificial g provisions) in polar orbits in 200 nautical miles altitude and sun synchronous orbits (inclination 97 degrees) in this same altitude.

SPACE STATION FLIGHT BOX



The Space Station in the zero-g mode will fly with the longitudinal or X axis perpendicular to the orbital plane with the Y axis in the direction of its orbital velocity vector. The Space Station will rotate at approximate orbital rate in order to maintain the Z axis joined to the ground in order to accomplish the earth looking experiments onboard from an attached module located on the +Z axis.

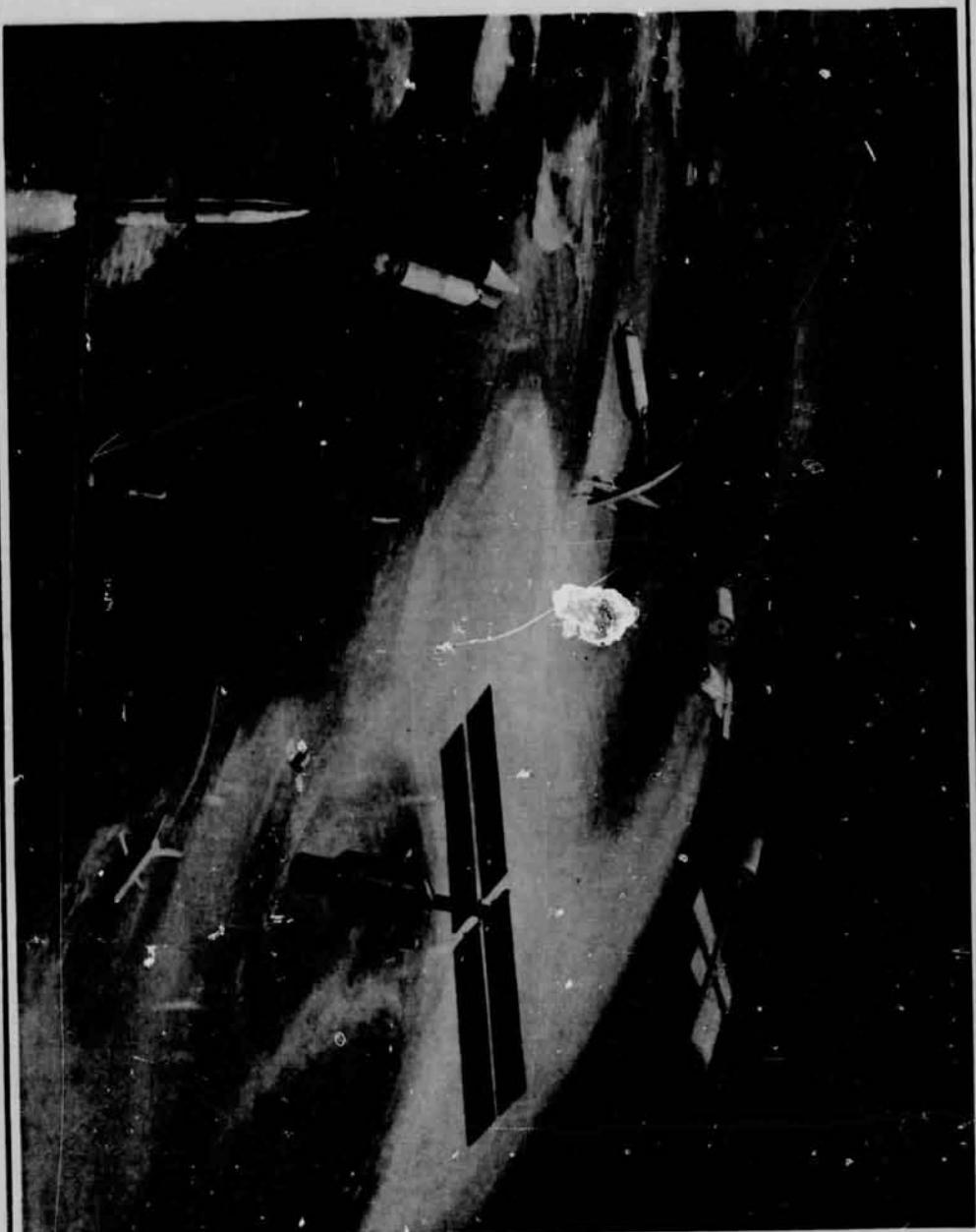
ZERO 'G' MODE



- 4 DECKS
- 12 CREW
- SOLAR ARRAY POWER
10,000 SQ FT
- 2 DEGREES OF FREEDOM
- FLIGHT MODE (PRIME)
X-PUP Z-LV



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SPACE STATION LAUNCH SEQUENCE

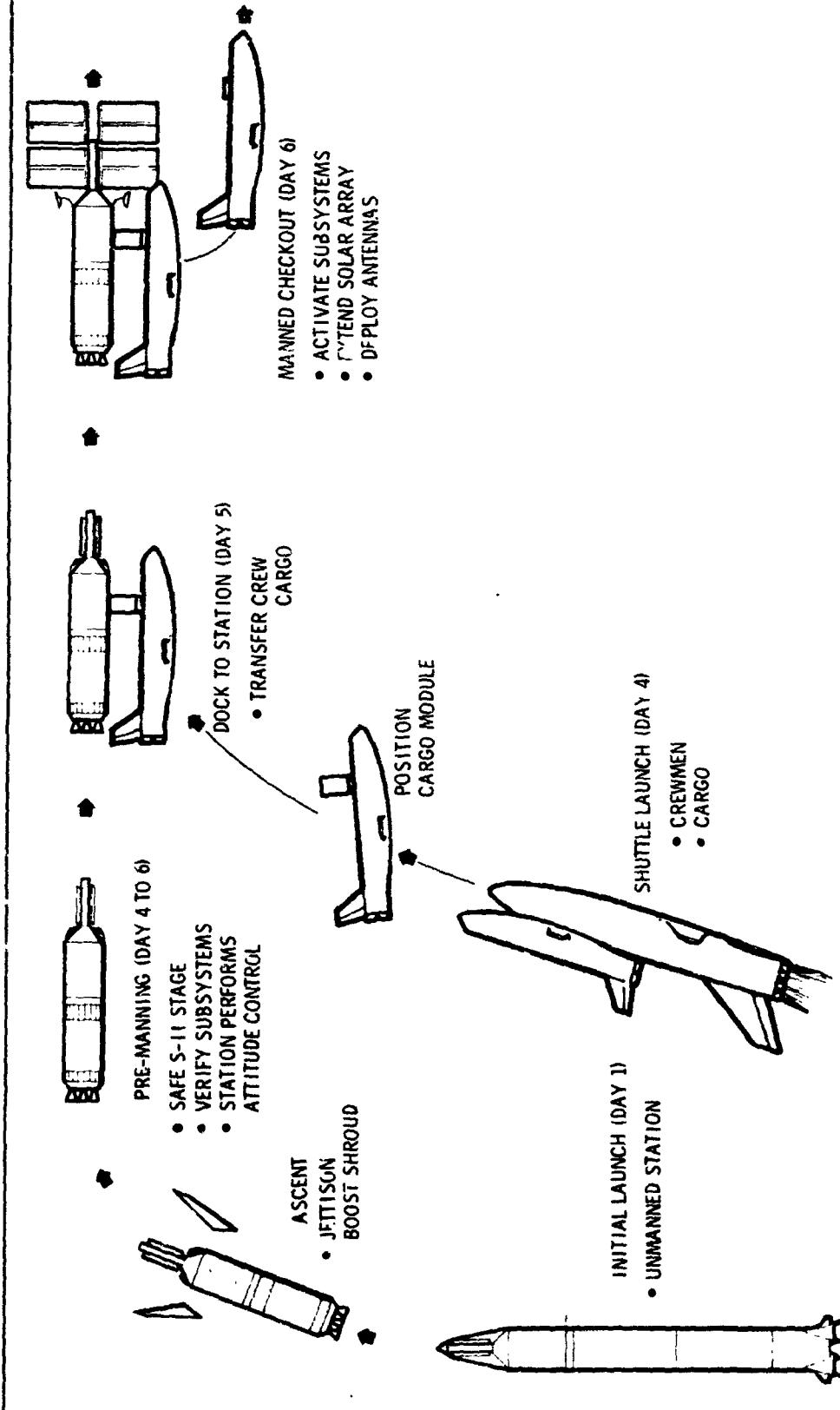
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The buildup of the Space Station is depicted in the accompanying two charts which show the various flight operations from the initial INT-21 launch of the unmanned station to the manning of the Station by the crewmen and the delivery of the cargo module via the Shuttle. The Shuttle then deorbits the S-II and continues to the base, leaving the completely operable space Station (with an attached cargo module) in its orbital configuration.

LAUNCH TO OPERATING MODE ZERO 'G'



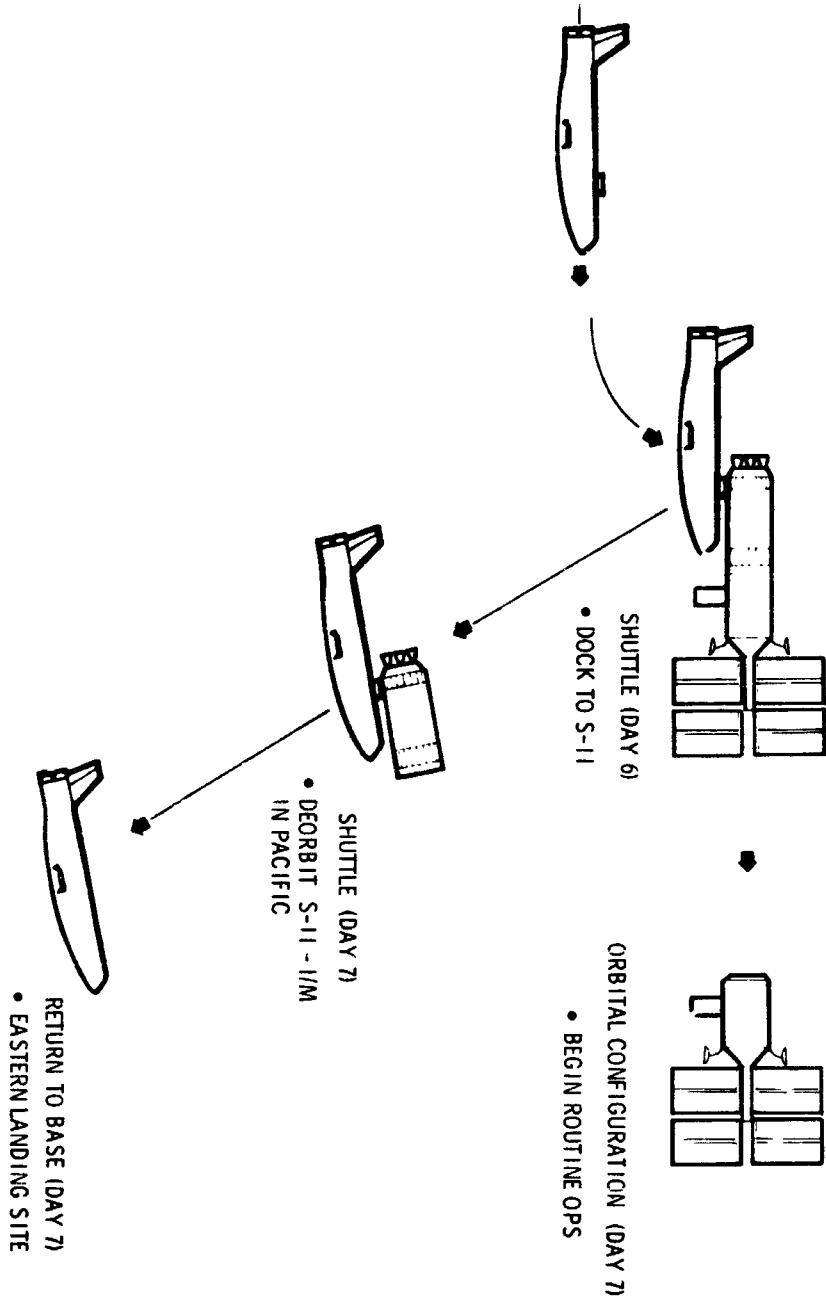
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LAUNCH TO OPERATING MODE (CONT)

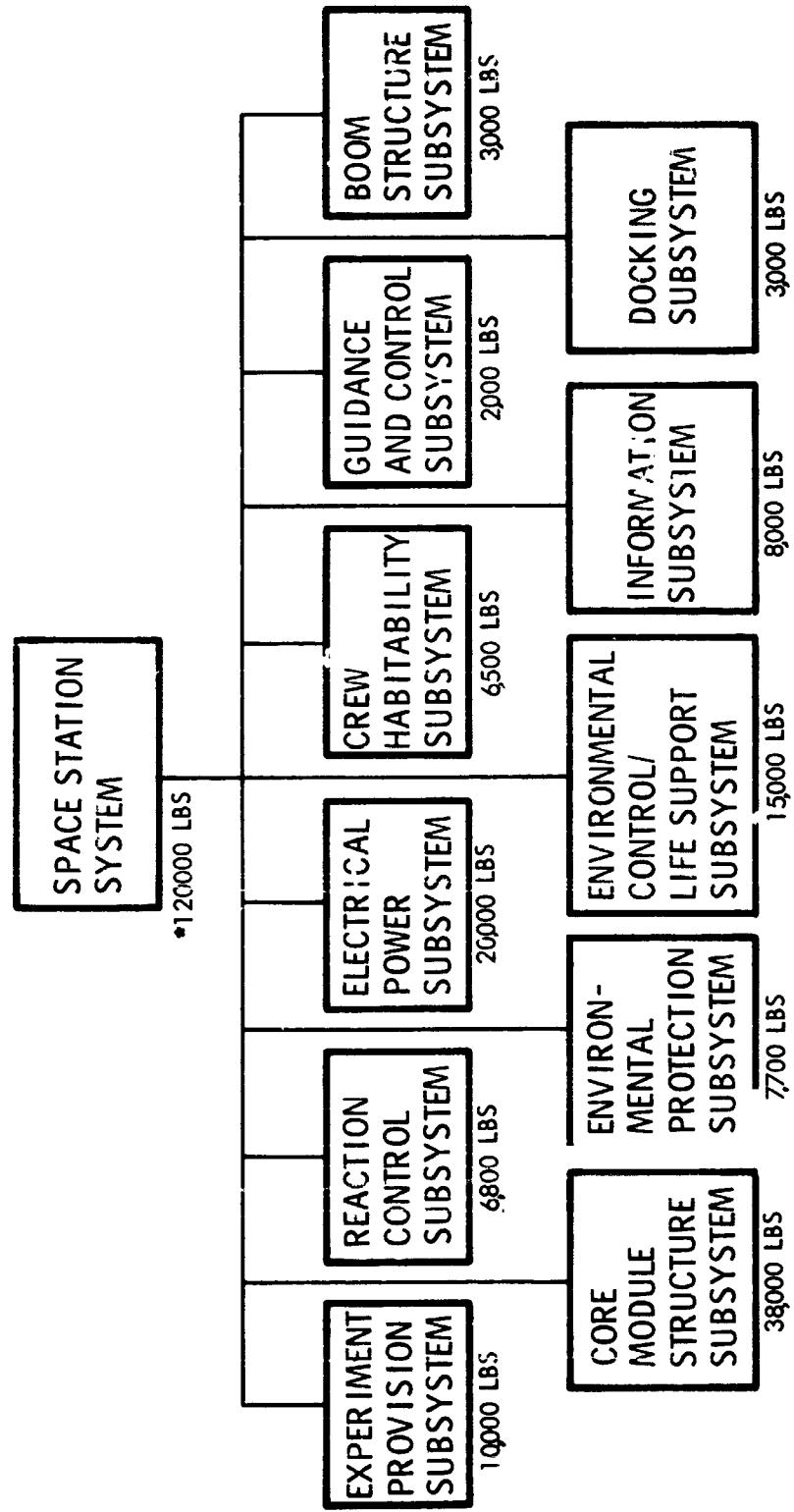
ZERO 'G'



PREFLIGHT CHECKLIST

Having briefly covered the overall configuration of the core module and some of the mission aspects, this presentation will now consider some of the Space Station subsystems. This chart shows a breakdown of the entire Space Station system into the various subsystems such as electrical power, information, and environmental control/life support, with a breakout of the weights of each one of these subsystems. The entire Space Station core module is currently being designed to 120,000 lb including 10,000 lb of experiment provisions onboard the initial launch. These weights include consumables for twelve men for 90 days. The weight limit of 120,000 lb still maintains a 50 percent margin for weight growth up to a lifting capability of an INT-21 (S-IC/S-II) launch vehicle. It is anticipated that this margin for weight growth will be taken up during the design and development phases prior to initial launch of the Space Station core module and that when the Space Station is launched, it will be at approximately 180,000 lb.

SPACE STATION SYSTEM



*INITIAL LAUNCH WEIGHT TARGET (LBS) INCLUDING 12 MAN CONSUMABLES FOR 90 DAYS



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The electrical power subsystem is obviously one of the most critical subsystems, and careful attention must be given to providing electrical power for various malfunction conditions. The design requirements are that the nominal power level of 25 kilowatts continuous must be available with one failure, the critical functions must be supported with two failures, and that a separate independent system for emergency use at a lower power level will be provided in the event of further malfunction. Further, it is desired to accomplish nominal maintenance functions without primary power shutdown and to provide a common electrical interface at the docking ports.

EPS MAJOR FUNCTIONAL/OPERATIONAL REQUIREMENTS

- NOMINAL POWER SUPPLIED WITH ONE CREDIBLE FAILURE
 - CRITICAL FUNCTIONS BUT REDUCED POWER WITH TWO FAILURES
 - SEPARATE, INDEPENDENT SYSTEM FOR EMERGENCY
 - SAFETY FEATURES - AUTOMATIC SWITCHING ON CRITICAL LOADS,
ISOLATION OF CRITICAL LIFE SUPPORT
 - NORMAL MAINTENANCE WITHOUT PRIMARY POWER SHUTDOWN
 - COMMON ELECTRICAL INTERFACE AT 5 DOCKING PORTS
 - MODES OF OPERATION
- | | | |
|----------------|----------|---------|
| PREMANNING | 6 DAYS | 5.1 KW |
| ARTIFICIAL "G" | 90 DAYS | 13.7 KW |
| NORMAL OPS | CONT | 25. KW |
| FAIL DEGRADE | CONT | 12.4 KW |
| EMERGENCY | 48 HOURS | 3 KW |

The selection of the electrical power subsystem is one which must be viewed at the programmatic level first to consider which would be the optimum selection for Space Station, Space Base, and the Planetary Mission Module and second to assess whether it is possible to select one system, or at the most two systems, which will satisfy the requirements through this evolving program. Solar arrays are clearly too cumbersome for the Space Base, whereas radioisotope Brayton could be used but with serious problems in the availability of the corresponding amount of radioisotope. The reactor Brayton system requires two launches for the Space Station and is a somewhat heavier system than the radioisotope Brayton for the Planetary Mission Module. As a result of the program-level implications, the selection of the electrical power system has been delayed and the activities under the North American Rockwell Phase-B contract are considering both reactor Brayton and solar arrays through the completion of the Phase B.

STATION EPS TRADE-OFF CONCLUSIONS

✓ NO OBVIOUS SINGLE DEVELOPMENT FOR STATION, BASE, & PMM

	STATION	BASE	PMM
SOLAR ARRAYS	ACCEPTABLE	NOT FEASIBLE	POSSIBLE
RADIOISOTOPE BRAYTON	ACCEPTABLE 2 LAUNCHES	QUESTIONABLE SELECTED	BEST POSSIBLE
NUCLEAR BRAYTON			

• SOLAR ARRAYS NOT FEASIBLE FOR BASE

• RADIOISOTOPE BRAYTON FOR BASE COULD BE DONE, BUT NOT LIKELY. MAY EXCEED PRACTICAL LIMIT FOR RADIOISOTOPE POWER

• NUCLEAR REACTOR BRAYTON REQUIRES 2 LAUNCHES & IS HEAVIER SYSTEM FOR PMM

✓ SIMULTANEOUS DEVELOPMENT OF REACTOR & ISOTOPE SYSTEMS TOO COSTLY FOR YEARLY BUDGET CONSIDERATIONS

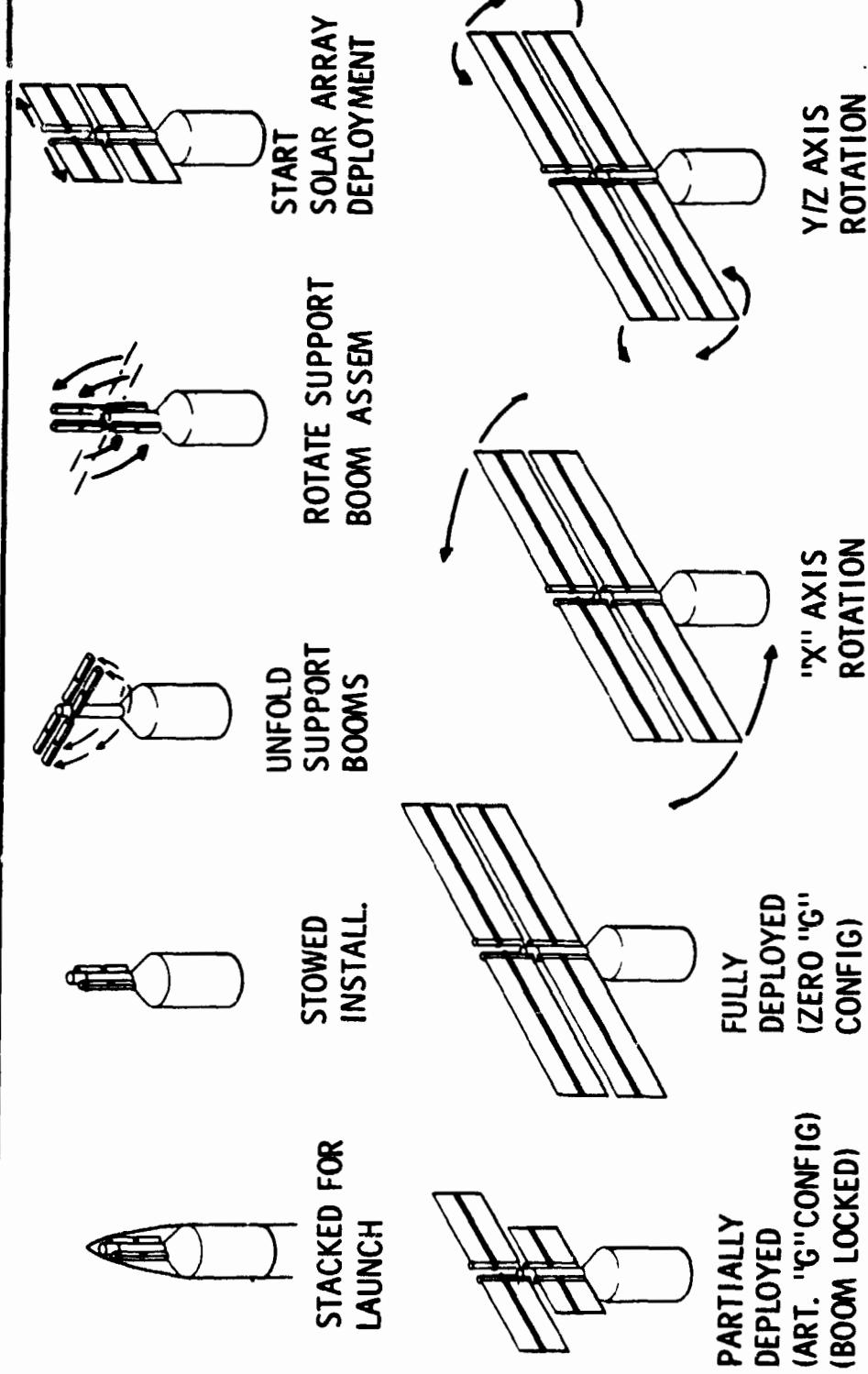
✓ CONTRACT DECISION IS TO CONDUCT PRELIMINARY DESIGN ON SOLAR ARRAY STATION

✓ REACTOR BRAYTON VIA AL'S BEING ADDED TO PRELIMINARY DESIGN TASKS



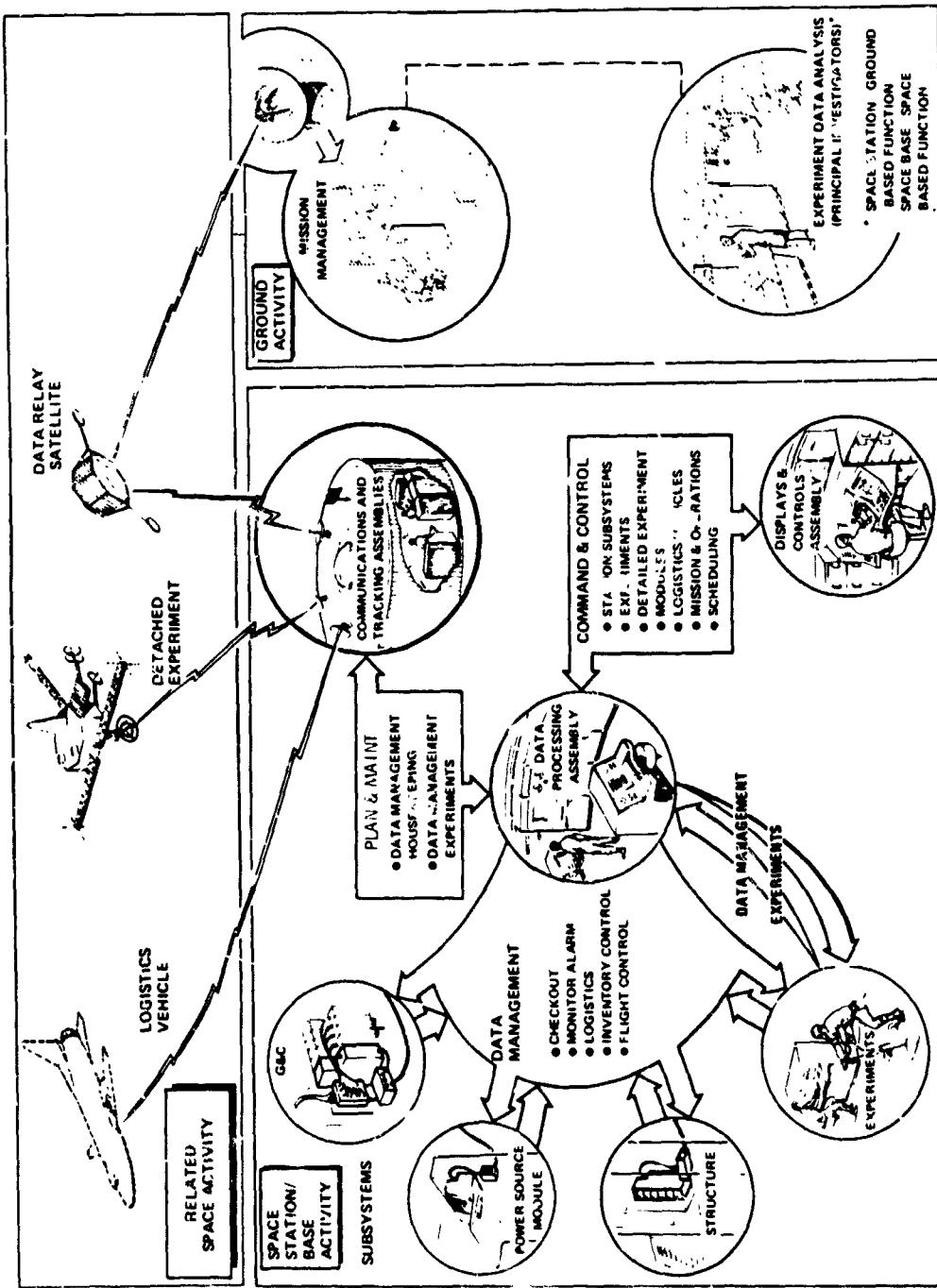
The solar array has a large deployed area of 10,000 square feet. The installation on the Space Station for launch must be compactly designed into the area enclosed by the boost shroud. The deployment of the solar array from the installation required for launch to the full rollout of the entire area and the operational orientation sequence is depicted in the pictures shown in this chart.

SOLAR ARRAY DEPLOYMENT/SEQUENCE



The primary objective of the Space Station mission, i.e., the generation of significant quantities of information, results in an information management system which is of a degree of complexity and sophistication that far exceeds anything experienced in previous space programs. This chart depicts the information flow onboard the Space Station and between the Space Station/ground and the other program elements such as the Shuttle detached experiment modules and the Cica relay satellite.

INTEGRATED INFORMATION MANAGEMENT SYSTEM



Space Division
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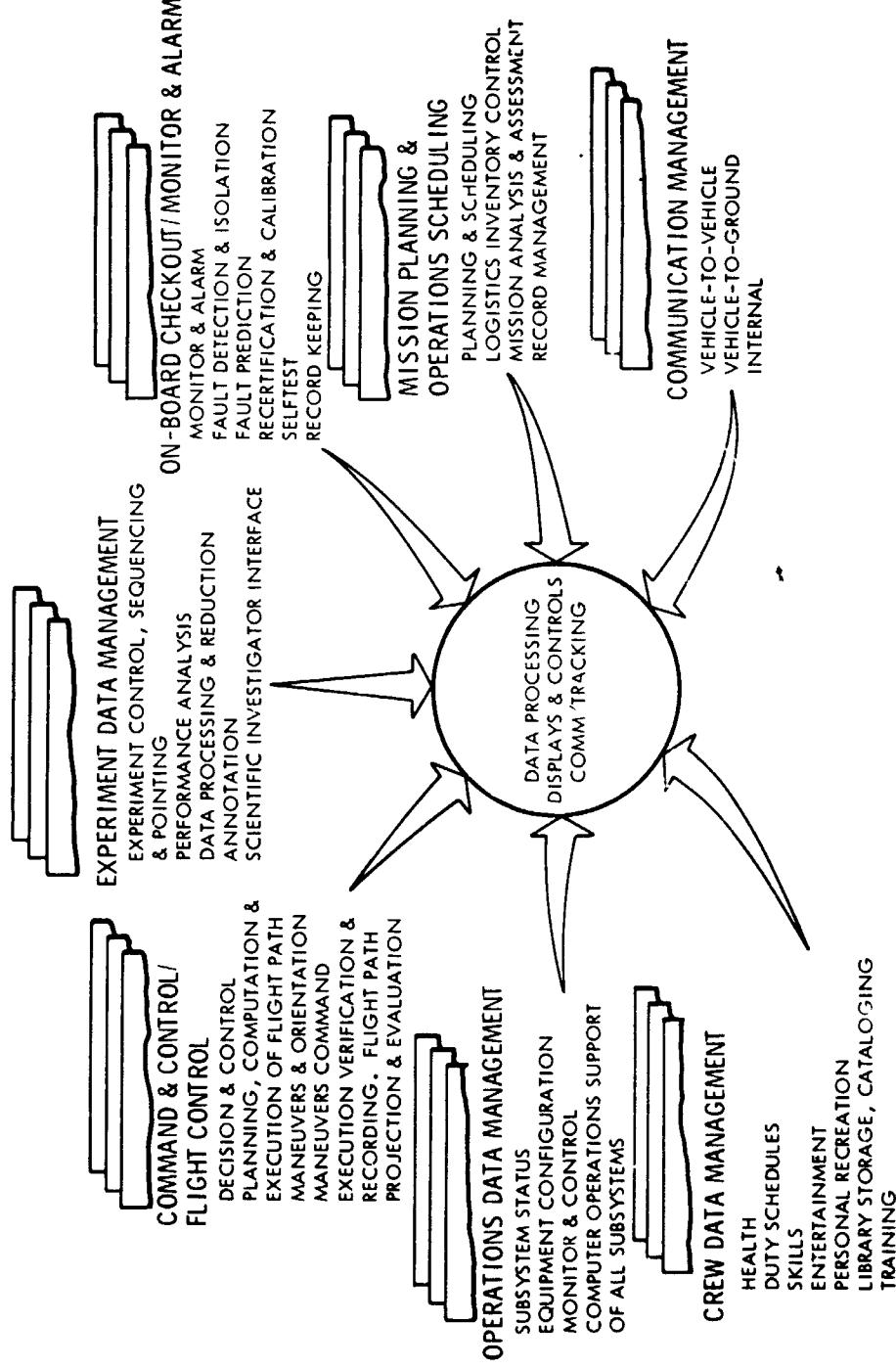


69PD92163 A



A closer look at some of the many functions accomplished by the information management subsystem reveals that they range from operations data management, considering such things as the computer operations support of all subsystems and subsystem statusing, to command-and-control experiment data management, onboard checkout/monitor and alarm, mission planning and operations scheduling, and the overall communications management. The information management subsystem includes all data processing functions, displays and controls, and the communication and tracking aspects.

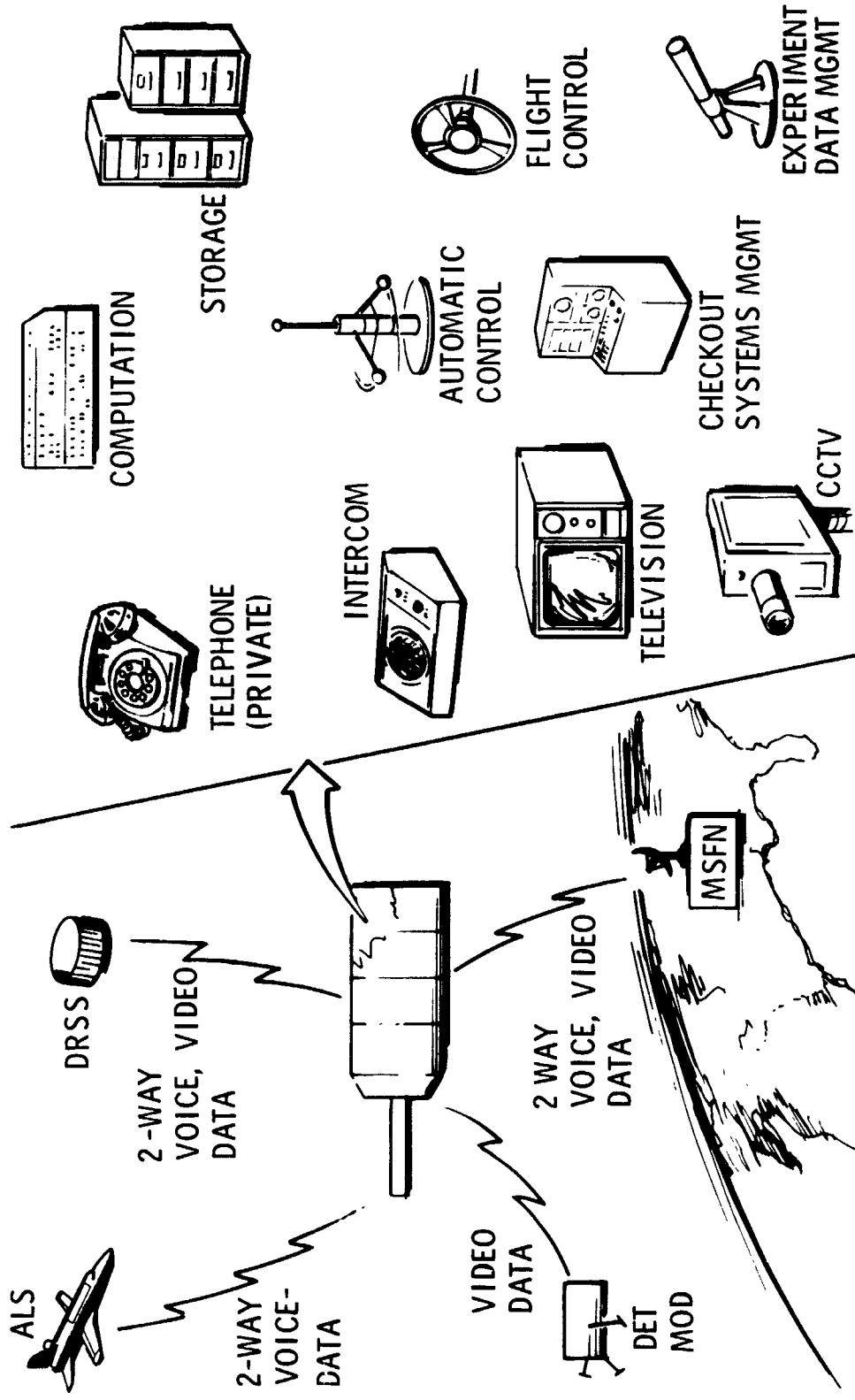
INFORMATION MANAGEMENT SUBSYSTEM (IMS/S) FUNCTIONS





This chart indicates symbolically the many service functions that are incorporated within the ISS communications and tracking to all external vehicles, to the DRSS, or direct to MSFN; an internal telephone system, with privacy and connection to the RF system for conversation with ground support personnel; an intercom; television for entertainment and CCTV for operations monitoring; and computation for automatic control of subsystems and experiments, for automating checkout and management of all subsystems, and for management of experiment data, as well as flight control of the Station and detached modules. Provisions are made to process, store, and prepare data for transshipment via the Shuttle.

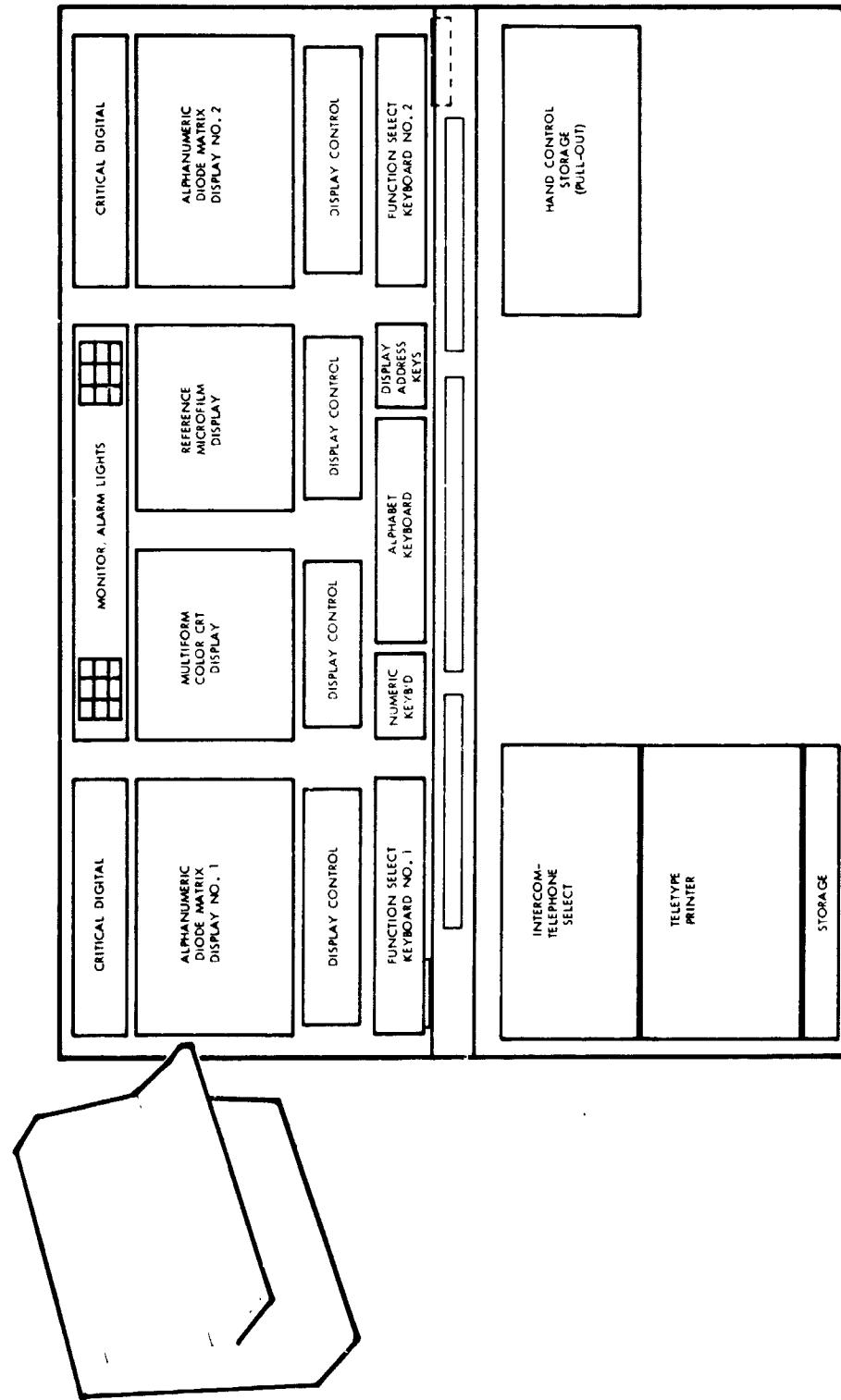
IMS MAJOR FUNCTIONAL/OPERATIONAL REQUIREMENTS



The standard command/control console is shown. Two operations consoles, to accommodate one to four working positions, are placed side-by-side in the Space Station command center. Consoles are multifunctional and identical; any crew involvement for any operation can be accomplished with any console. Multiple working positions are needed to accomplish several operations concurrently. Associated equipment is installed in racks. The commander position can view and evaluate any console display for overall situation evaluation.

The control centers (both primary and experiment) are identical in construction and capabilities so that the experiment control center can back up the primary control center for all experiment management operations. Display forms include a US-standard TV color CRT, capable of both direct video and synthetic video (alphanumeric, graphic, or symbolic) and alphanumeric page-format, dynamic form made up of discrete light-emitting diodes in a matrix, as well as more conventional metric and event forms. Keyboards in several forms are provided for operator interaction with the data processor, and thus to all other control points.

SPACE STATION COMMAND CENTER



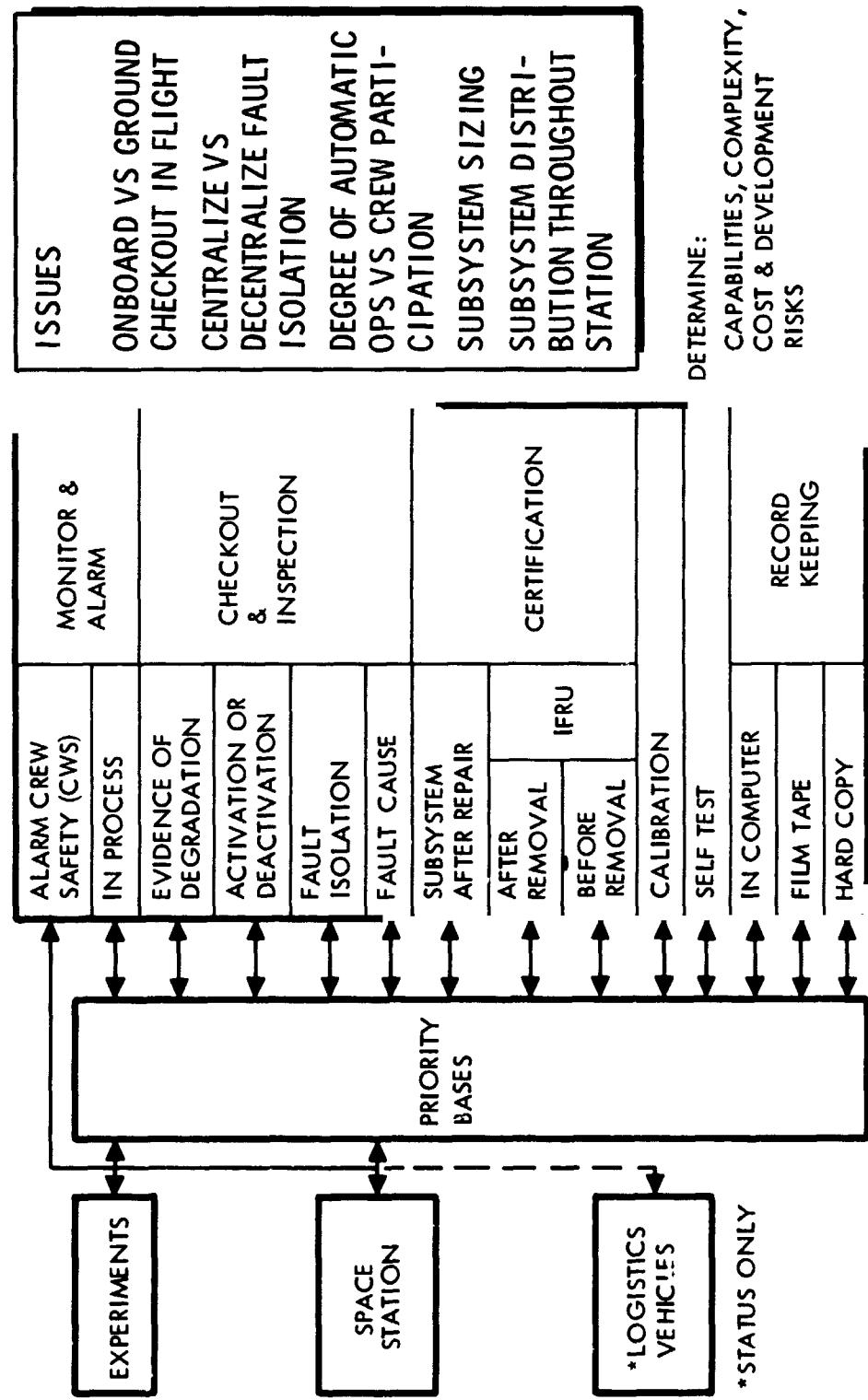
Space Division
North American Rockwell

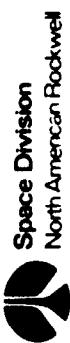
50PDS104258 A



This chart depicts the scope, functions, and issues of the onboard checkout special emphasis area. The onboard function consists of monitor and alarm, checkout/inspection, certification, calibration, self test, and record keeping. Each of these are further defined as to when they are performed and the depth to which each is accomplished. It will be noted that all the functions can be performed or assigned a priority except for the monitor and alarm function which affects crew or equipment safety. This safety monitoring function must be continuous, on a noninterference basis, without manual override or interruption.

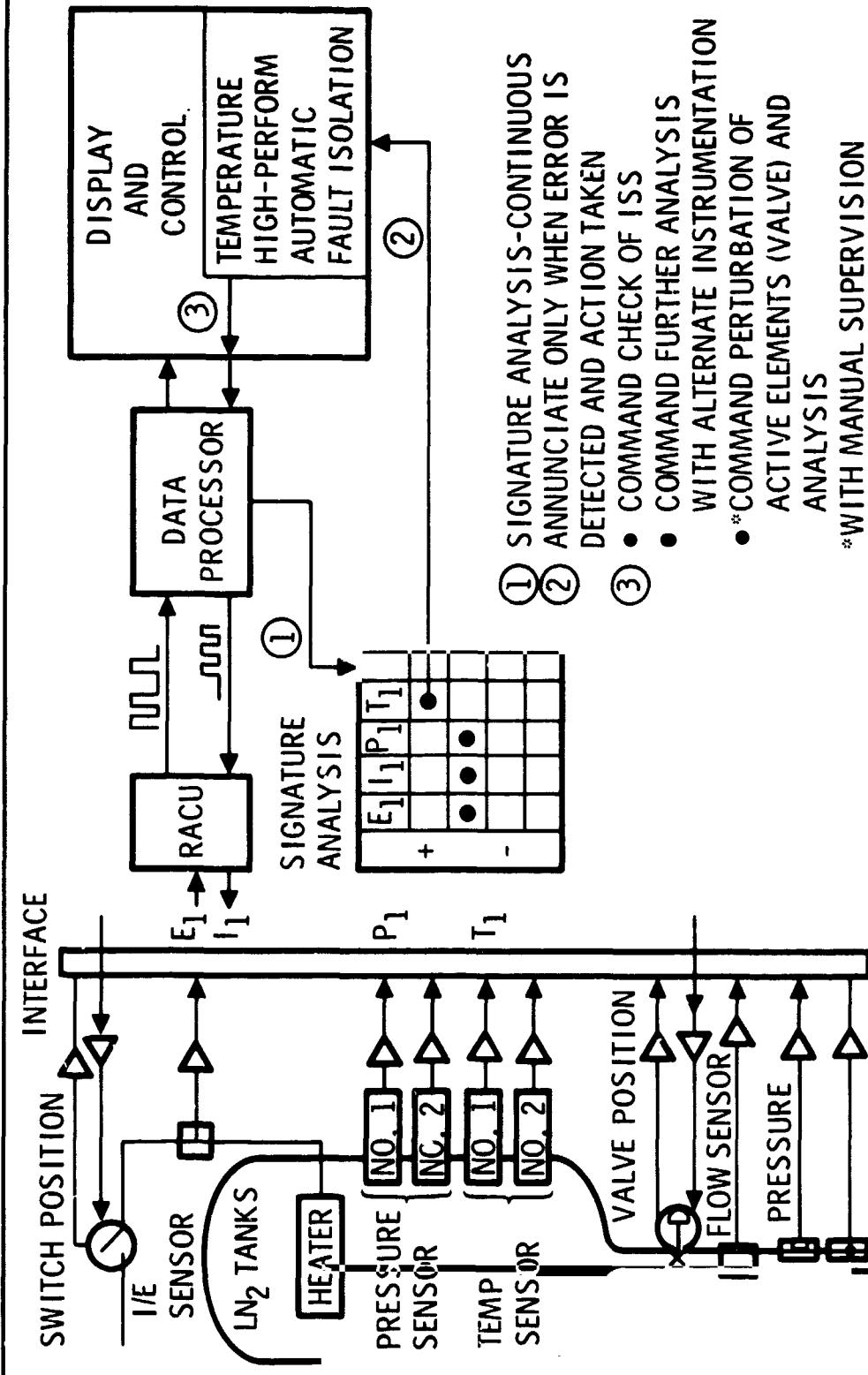
SPECIAL EMPHASIS ONBOARD CHECKOUT





This chart shows a concept for accomplishing the onboard checkout of one subsystem IFRU, an LN₂ tank. It is assumed that failure analysis has shown that four parameters are necessary to perform the monitor/alarm function; these parameters are the voltage and current in the heaters, and the tanks' pressure and temperature. These parameters are measured continuously and compared against preset limits. As long as the values of the parameters stay within the limits, the IFRU is operating satisfactorily. This comparison of the parameters against high and low limits is called the signature of the IFRU. When the signature is not correct, this fact is displayed to the crew along with the action being taken or required (for example, "The temperature is high - automatic fault isolation is being performed"). The ISS would automatically self check the ISS and perform further analysis with alternate instrumentation. If the fault still was not isolated, this fact would be annunciated for the crew and an alarm sounded.

ONBOARD CHECKOUT PROCESS





The environmental-control and life-support subsystems represent a significant stepping complexity beyond the open-loop type subsystems that have been used on previous manned space programs. The recovery of oxygen and water to minimize the logistics supply requirements, the responsibility for accomplishing the thermal control functions of both the subsystems and the experiments, and the special life-support requirements for situations such as EVA/VA and emergency situations must all be considered.

ENVIRONMENTAL CONTROL & LIFE SUPPORT

SCOPE & MAJOR GUIDELINES

SCOPE

- HABITABLE ENVIRONMENTAL CONTROL
- OXYGEN & WATER RECOVERY
- UTILITY PROVISIONS FOR CREW ~ WATER, WASTE, HYGIENE, FOOD PREPARATION SUBSYSTEM ~ THERMAL CONTROL EXPERIMENT ~ THERMAL CONTROL, WATER RECOVERY
- SPECIAL LIFE SUPPORT EVA/IVA WATER & OXYGEN EMERGENCY OXYGEN, FOOD, WATER FIRE DETECTION & CONTROL

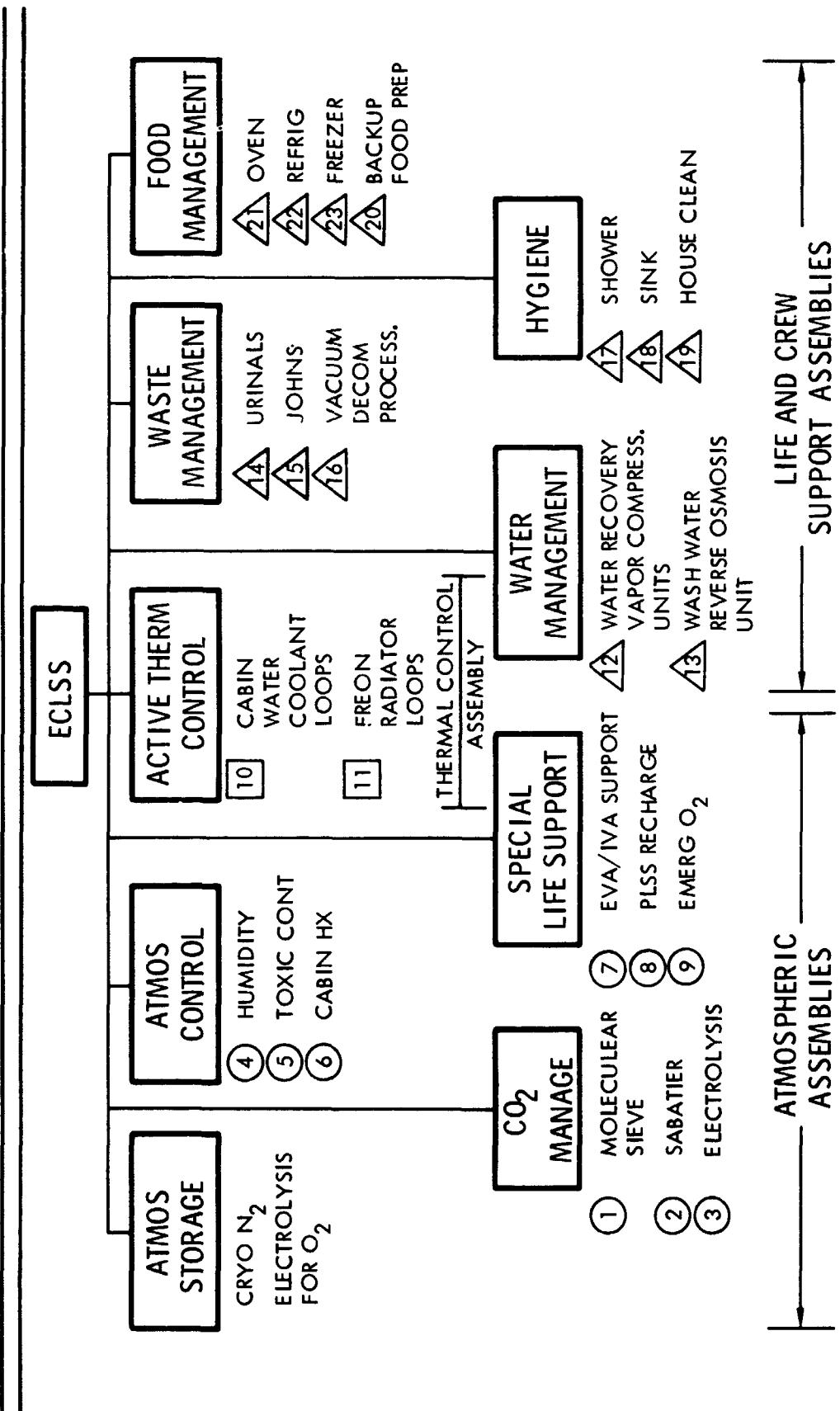
MAJOR GUIDELINES

- 2 MAN CREW ~ IN 1977
- 6 MONTHS EXPENDABLE CAPACITY
- OXYGEN & WATER RECOVERY
- ATMOS TEMP 65 TO 75, 8-12 MM HG PP WATER VAPOR
- CO₂ CONCENTRATION 5.0 MM HG NOMINAL



Shown here is a breakdown of the many assemblies which make up the environmental control/life support subsystem. They break down generally into the atmospheric assemblies, the thermal control assemblies, and the life and crew support assemblies.

ENVIRONMENTAL CONTROL & LIFE SUPPORT ASSEMBLIES



The guidance and control subsystem is responsible for determining the state vector (velocity and position) and for calculating the guidance commands for both the Station and the free-flying experiment modules and, in addition, is responsible for generating the signals necessary for attitude hold and maneuvering. The artificial g operational evaluation imposes additional requirements on the guidance and control subsystem. There is a strong desire for autonomous navigation and a highly automatic guidance and control function. There are two primary orientation modes to be considered, the primary one being local level, but another one representing an inertial-hold mode to be used for certain experiments.

GUIDANCE & CONTROL SUBSYSTEM

SCOPE & MAJOR GUIDELINES

- **SCOPE**

- STATE VECTOR DETERMINATION & GUIDANCE COMMANDS

- STATION
 - FREE FLYING MODULES
- STATION CONTROL
- ATTITUDE HOLD
 - MANEUVERS
- ARTIFICIAL "G"
- SPIN - DE-SPIN
 - WOBBLE DAMPING
 - MOMENTUM VECTOR CONTROL

- **MAJOR GUIDELINES**

- AUTONOMOUS NAVIGATION

- AUTOMATIC GUIDANCE & CONTROL

ORIENTATION MODES: LOCAL LEVEL & INERTIAL



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SOPDS104229

This chart shows the identity of the assemblies in the Space Station system. The inertial reference assembly includes the strapdown gyros and accelerometers and the associated preprocessor. The optical reference assembly includes star trackers, horizon scanners, a telescope/sexant, a laser docking radar, and a preprocessor. The computation requirements block represents the software associated with G&C computations performed within the ISS computers. The control moment gyro (CMG) assembly includes the three double gimballed CMG's as well as the supporting electronics. The RCS electronics assembly includes solenoid drivers, igniters, and a preprocessor.

Horizon sensor optics and automatic star tracker optics are located amidships, where the bulkheads of the two pressure volumes provide maximum rigidity. Minimum earth/orbit distortion here will mean slight change from the ground calibration/alignment of these sensors. This location also permits the horizon sensors to view the horizon without obstruction from cargo or experiment modules. Location of the star trackers at about 45 degrees in the -Z, -Y quadrant gives an unobstructed forward view of the star-field.

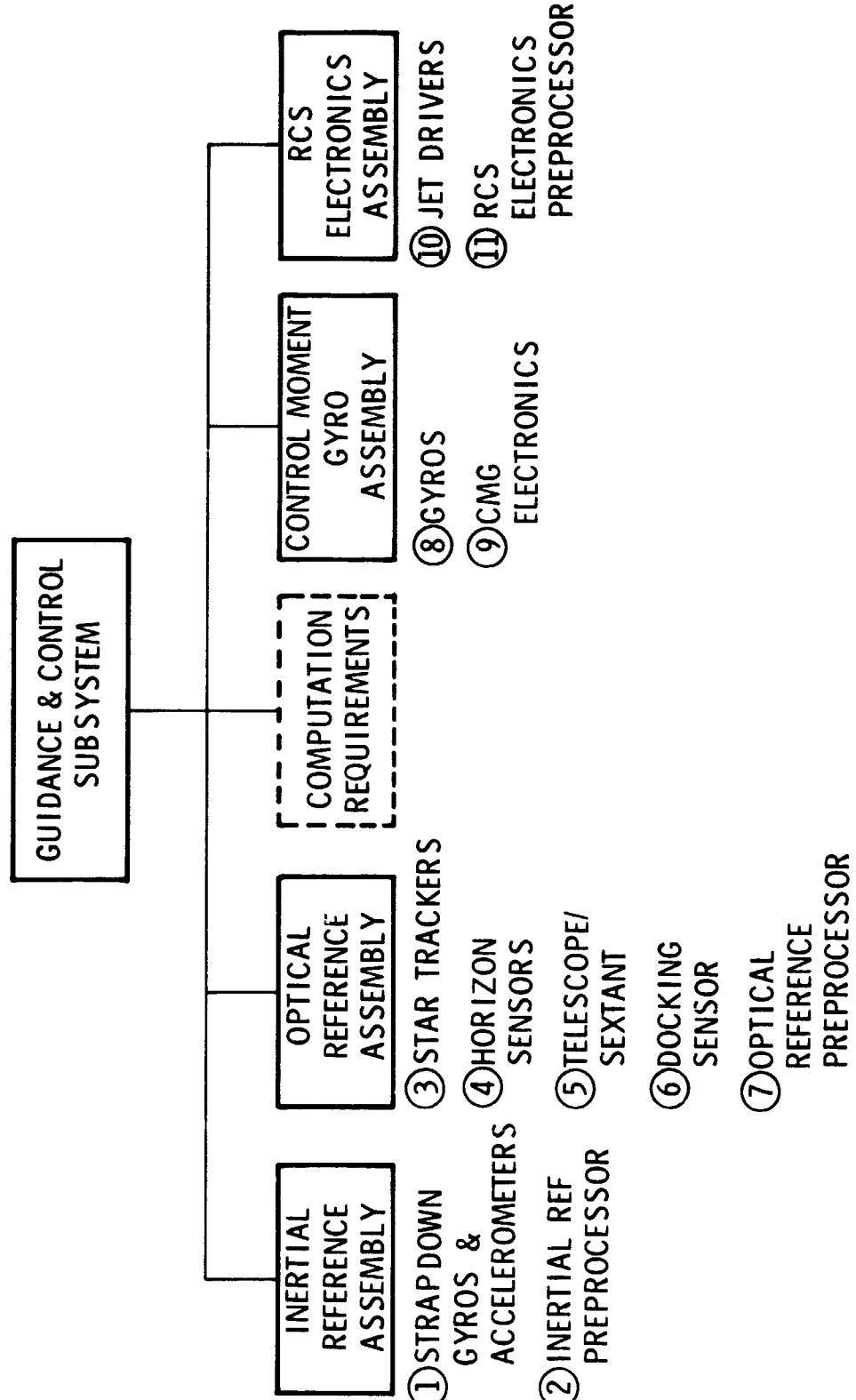
Electronics for these sensors are in Deck 2 giving close access to computers in the primary command and control center on this deck.

The telescope/sexant and inertial reference assembly are located with the back-up control center and computers on Deck 4 in the second pressure volume. A location in the +Z, -Y quadrant permits inflight calibration versus the automatic star trackers by common star sightings, facilitates calibration to the earth experiments module on this deck, and permits use of the telescope/sexant for obtaining position data on earth targets of interest.

There are two RCS quads at each end of the core module. The RCS driver electronics is therefore divided into four boxes, each located near its quad to minimize high-power wiring length and EMI, but within the pressure hull to facilitate maintenance.

Control moment gyros (CMG's) and their control electronics box are located in the upper torus to minimize acoustic disturbance, yet obtain as much stiffness as possible between themselves and the earth-pointing experiments and the inertial reference, in Deck 4 adjoining the torus.

GUIDANCE AND CONTROL ASSEMBLIES



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50PDS104230

This chart shows the scope of the reaction control subsystem (RCS) and summarizes the key items in the Guidelines and Constraints document that affect this particular subsystem. The RCS provides the thrust required for stabilization and attitude control, docking torque control, orbit maintenance, control moment gyro desaturation, and maneuvers. It also provides spin up, despin, and momentum vector control during the artificial g assessment.

The storage of all the onboard cryogenics has been assigned to the reaction control subsystem, including nitrogen for cabin atmosphere leakage makeup, oxygen and hydrogen propellants, and hydrogen for the EC/LSS Sabatier reactor.

No guidelines specifically refer to the RCS system, but ground rules (derived from experiments) required that engine plume impingement and contamination be minimized.

REACTION CONTROL SUBSYSTEM

SCOPE & MAJOR GUIDELINES

- **SCOPE**

PROVIDE THRUST FOR:

- STABILIZATION & CONTROL
- CONTROL OF DOCKING TORQUES
- ORBIT MAINTENANCE
- CONTROL MOMENT GYRO DESATURATION
- MANEUVERS
 - ARTIFICIAL "G" SPIN UP & DE-SPIN
 - ARTIFICIAL "G" MOMENTUM VECTOR CONTROL

PROVIDE CRYOGENIC STORAGE

- **MAJOR GROUND RULES**

ENGINE LOCATIONS WHICH MINIMIZE PLUME IMPINGEMENT PROBLEMS

PROPELLANTS WHICH MINIMIZE CONTAMINATION



SOPDS104235

The crew habitability area is being handled as a subsystem to make sure it receives the proper emphasis in overall Space Station design considerations. The scope of this subsystem's involvement includes the crew and all the equipment and facilities required to support them in efficiently and effectively performing their duties. The chart shows some of the major elements within this area.

The major guidelines, derived from the basic guidelines and constraints document, provide directions for providing the crew with an earthlike work/home environment to the greatest extent possible within the limitations of the Space Station and mission restraints.

CREW / HABITABILITY SUBSYSTEM

SCOPE

- CREW
- PERSONAL EQUIPMENT
- MOBILITY & RESTRAINT DEVICES
- CREW FURNISHINGS & GENERAL EQUIPMENT
- FOOD
- RECREATION / EXERCISE / MEDICAL FACILITIES
- REQUIREMENTS FOR CREW WELL BEING

MAJOR GUIDELINES

- AREA ALLOCATION, ARRANGEMENT, & CREW ACCOMMODATIONS CONSISTENT WITH GOOD ARCHITECTURAL DESIGN & DECORATOR PRACTICES
- PROVIDE EARTHLIKE WORK/HOME ENVIRONMENT
- PRIVACY IN STATEROOMS / PERSONAL HYGIENE AREA
- MINIMIZE EFFECTS OF ARTIFICIAL GRAVITY

The configurations of the staterooms for the general crew, the Station commander, and the experiment coordinator reflect the guidelines as previously defined. Each man is provided with an individual stateroom that is isolated from equipment that are considered "noise makers" (i.e., rotating waste management components, high-flow-rate ducting, etc.). Privacy is further increased by locating the staterooms and other commonly frequented Station areas so as to minimize traffic flow past the living quarters. In addition, doors are provided to close off these quarters from adjacent areas at the discretion of the individual crewman.

A pleasant, earthlike environment is developed by using color, lighting, and proven decoration techniques to complement the appearance of the rooms. Furnishings provide convenient seating, sleeping, recreation, and work areas, while ample storage is provided under each bunk and in appropriately located closets and drawers. Each stateroom is equipped with controls to regulate both temperature and airflow for the comfort of the individual inhabitants. Television, tape deck, and intercom facilities are included to enhance the livability of the staterooms.

The furnishings and room arrangements are configured to facilitate the general housekeeping functions associated with bedroom/living quarters.

The commander and experiment coordinators' staterooms are provided with additional work desk space and seats to permit consultation and conducting of general business activities. In addition, these quarters have private personal grooming areas as well as some critical control station (experiment) monitoring devices.

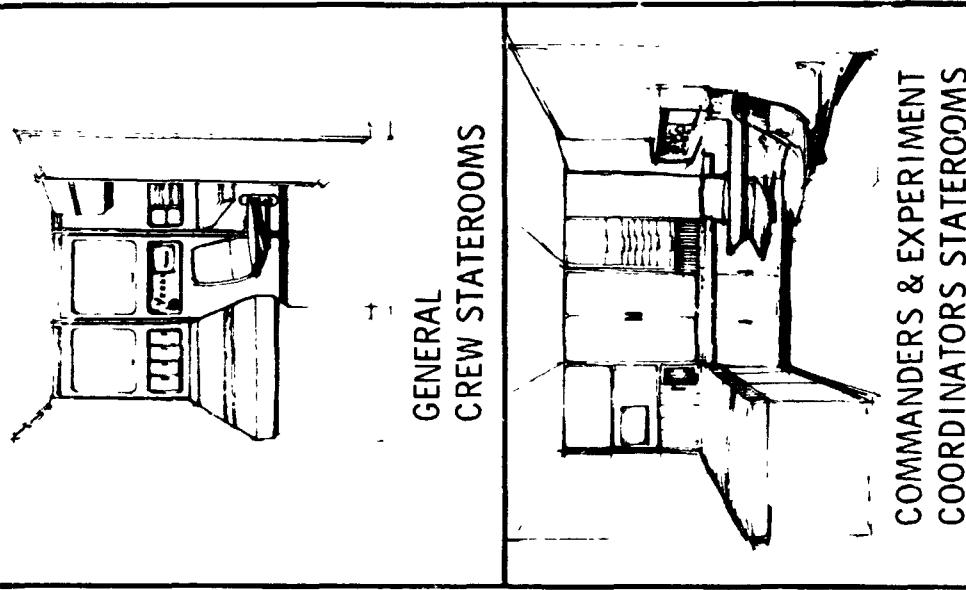
STATEROOMS

PRIVACY

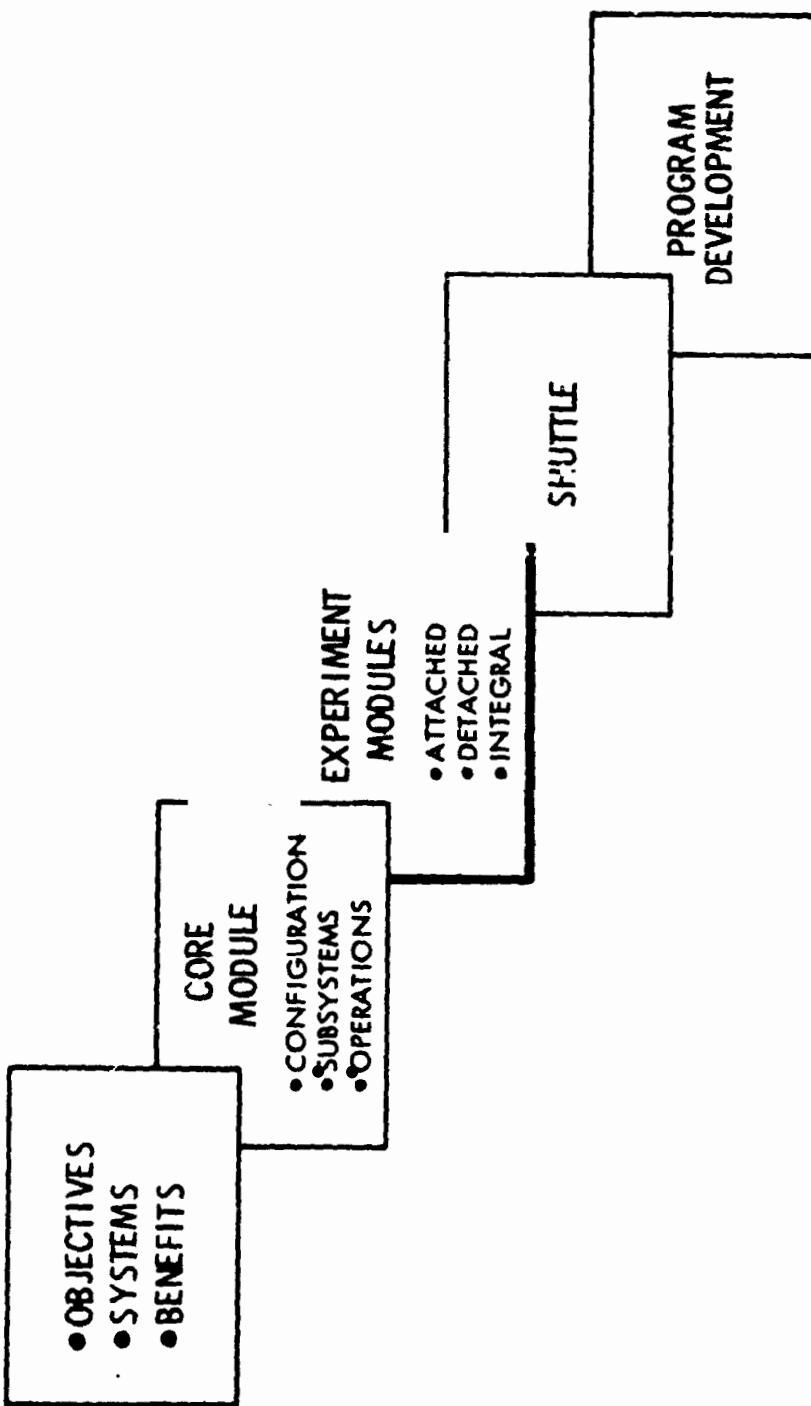
- INDIVIDUAL STATEROOMS
- "NOISE MAKERS" ISOLATED FROM STATEROOMS
- MINIMUM TRAFFIC FLOW

PLEASANT ENVIRONMENT

- COLOR/LIGHTING/DECORATION
- AMPLE PERSONAL STORAGE
- COMFORTABLE ADJUSTABLE BED
- DESK/CHAIR/TV
- EFFICIENT HOUSEKEEPING
- ADJACENT PERSONAL HYGIENE AREAS
- INDIVIDUAL TEMPERATURE CONTROL
- PERSONAL GROOMING FACILITIES
(COMMANDERS & EXP COORDINATOR
STATEROOMS)



PRES EN TATION OUTLINE





The Space Station experiment data book (NASA "Blue Book") is used to define a representative list of experiments which are used in the Space Station program definition activity in order to ensure that the program can accommodate and accomplish a wide range of experiments/applications activities. It is important to recognize that this blue book only represents a typical list and that the primary emphasis of the Phase B is to ensure that the Space Station program offers a research facility. The experiment data book is organized into approximately 25 functional program elements where one functional program element represents a group of experiments related by discipline and by similar requirements.

SPACE STATION EXPERIMENT DATA BOOK

20PDS100283

F_UNCTIONAL P_ROGRAM E_LEMENT

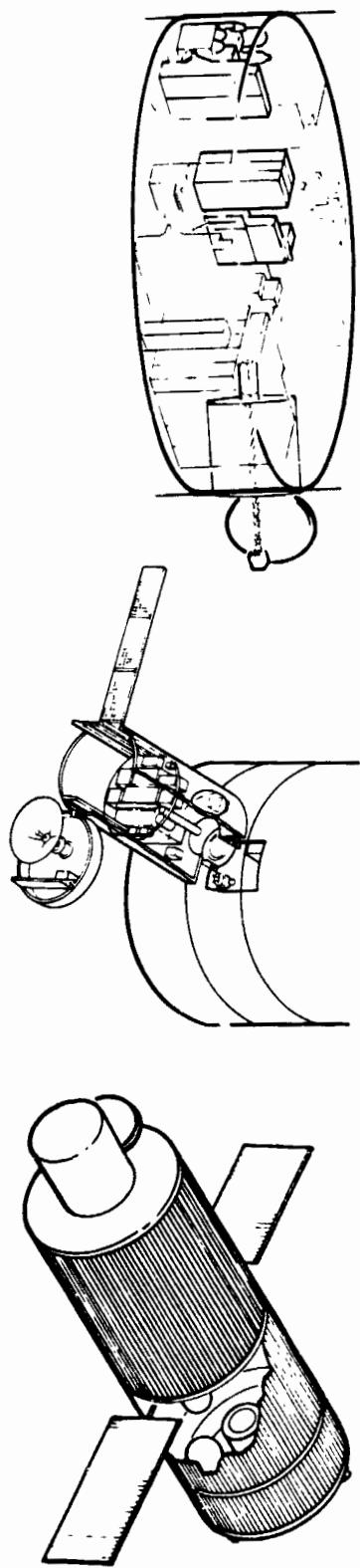
A GROUP OF RELATED EXPERIMENTS

- BY DISCIPLINE
- BY SIMILAR REQUIREMENTS



The experiments operating on the Space Station program can either be accommodated integrally to the core module in a module that is attached to one of the core module docking ports on a semipermanent basis but which can easily be replaced when its usefulness has expired and in detached flying-type modules which periodically rendezvous and dock with the Space Station core module for periodic module and experiment maintenance, update, film/tape reloading, etc.

EXPERIMENT OPERATING MODES



INTEGRAL

ATTACHED

DETACHED



The experiment data book covers the spectrum of disciplines from astronomy through advanced technology and manned space flight engineering and operations activities. Each of these disciplines has certain unique requirements which have to be accommodated in the Space Station program and which represent the drivers to the Space Station. For example, astronomy requires a very high pointing stability and an uncontaminated field of view, whereas the bioscience research program requires long time periods at a relatively low acceleration level (approximately 10^{-5}). Manned space flight engineering and operations requires the use of a hangar which represents a large volume.

EXPERIMENT REQUIREMENTS

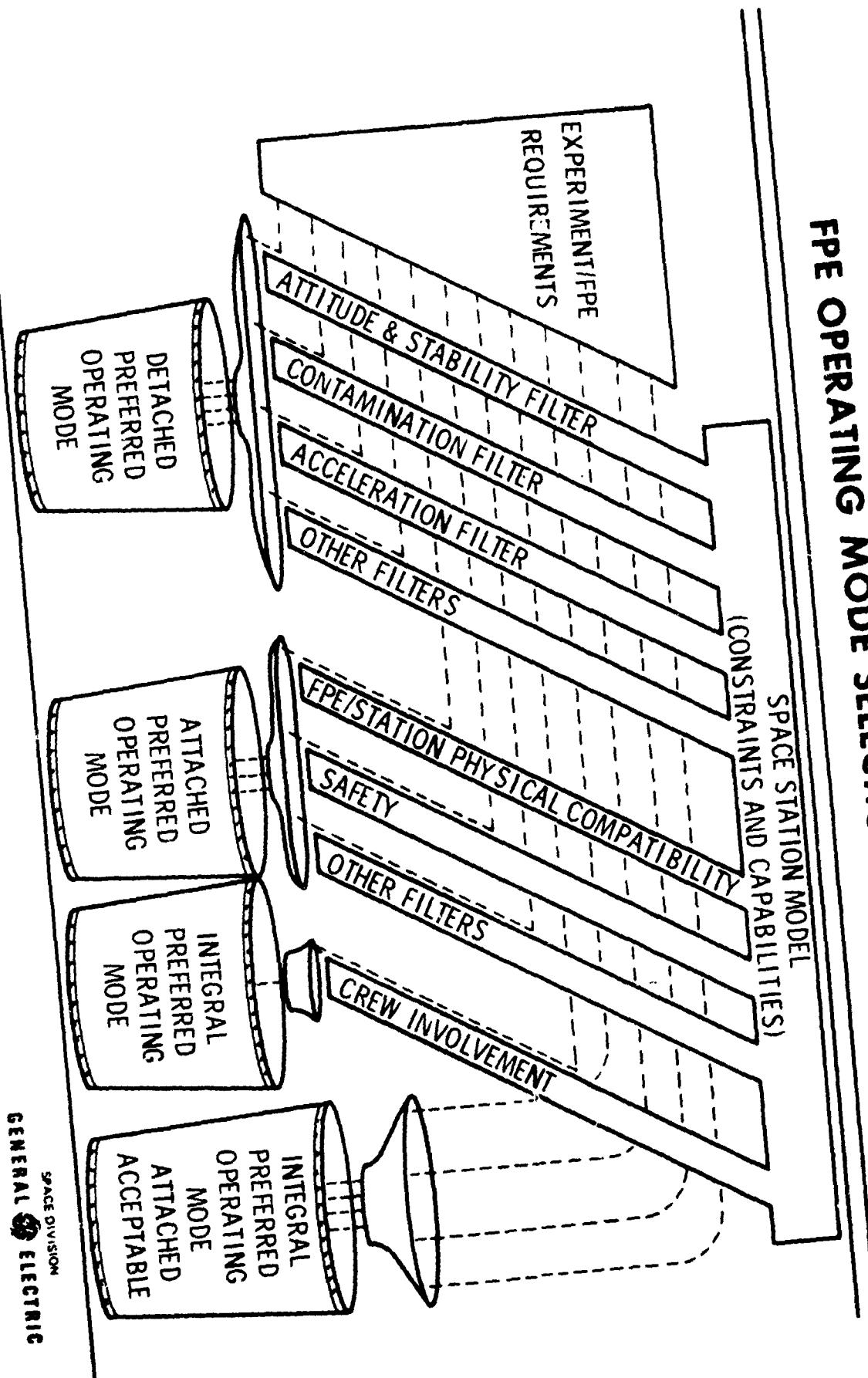
DISCIPLINE	REQUIREMENTS
ASTRONOMY	HIGH STABILITY UNCONTAMINATED VIEW
SPACE PHYSICS	MODERATE STABILITY LARGE SENSORS
BIOSCIENCE	LONG-TERM LOW ACCELERATION CENTRIFUGE
EARTH APPLICATIONS	LARGE SENSOR ARRAY MODERATE STABILITY
AEROSPACE MEDICINE	MAN IN VARIOUS ENVIRONMENTS LARGE MANNED CENTRIFUGE
MATERIALS SCIENCE & PROCESSING	LOW ACCELERATION
ADVANCED TECHNOLOGY	CONTROLLED ACCELERATION EXTERNAL SENSING OF ENVIRONMENT
MANNED SPACE FLIGHT ENGINEERING & OPERATIONS	LARGE VOLUMES



A systems engineering approach has been taken to match the requirements of the experiment program to the capabilities and limitations of the Space Station; and a series of filters, such as the Space Station capabilities for holding attitude or for providing an uncontaminated field of view, are used to determine which of the FPE's must go in a detached operating mode, attached mode, or integral to the core module.

FPE OPERATING MODE SELECTION TRADE STUDY

20PDS99873



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To illustrate the results of the systems engineering approach mentioned on the previous chart, those FPE's are shown here which the analysis indicates should operate detached from the core module together with the driving factors which result in this decision.

SUMMARY-DETACHED OPERATING MODE

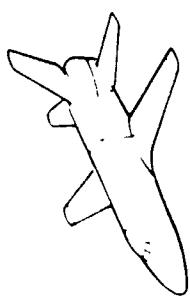
DISCIPLINE/EXPERIMENT	DRIVING FACTOR(S)
<u>ASTRONOMY</u> <ul style="list-style-type: none">• 5.2 ADVANCED STELLAR ASTRONOMY• 5.3 ADVANCED SOLAR ASTRONOMY• 5.4 UV STELLAR ASTRONOMY• 5.21 IR STELLAR ASTRONOMY	STABILITY / CONTAMINATION STABILITY CONTAMINATION CONTAMINATION
<u>SPACE PHYSICS</u> <ul style="list-style-type: none">• 5.7 PLASMA PHYSICS & ENVIRON (PERTURBATION)• 5.8 COSMIC RAY PHYSICS <u>EARTH APPLICATIONS</u> <ul style="list-style-type: none">• 5.12 REMOTE MANEUVERING SUBSATELLITE	NATURE OF EXPERIMENT MAGNETIC INTERFERENCE NATURE OF EXPERIMENT

Of the approximately twenty-five FPE's in the Space Station experiment book, ten need to be accommodated integrally within the Space Station core module, and the remaining fifteen have been analyzed to provide a method for their accommodation in the next number of experiment modules considering factors such as the Shuttle payload, weight and volume characteristics, and the Space Station subsystem characteristics. This analysis showed that six out of the fifteen FPE's could be accommodated best in eight detached modules and the remaining nine FPE's in seven attached modules. Three of the seven attached modules had unique requirements so that these were not candidates for further analysis to identify a common module. The remaining four modules and the eight detached modules were then analyzed to identify the most efficient design approach which would provide the optimum degree of commonality.

LEAST NUMBER OF MODULES

50PDS104152

• APPROACH



ALS CHARACTERISTICS

EIGHT DETACHED
MODULES
REQUIRED

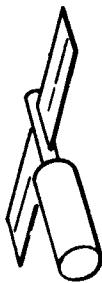
6 FPE'S

LEAST NUMBER
OF
MODULES

15 FPE'S

SEVEN *ATTACHED
MODULES
REQUIRED

9 FPE'S



STATION SUB SYSTEM
CHARACTERISTICS

* THREE "UNIQUE"
MODULES REQD



NR has generated design sheets for the experiment provision subsystem, which summarizes the capabilities and provisions available for the support of experiments in each of the Space Station subsystem areas. The type of support supplied by each subsystem for the integral, attached, and detached operating modes is summarized in the table shown.

STATION EXPERIMENT PROVISIONS SUBSYSTEM (XPS)

5OPDS104154.A

- SCOPE

EXPERIMENT PROVISIONS SUBSYSTEM PROVIDES EXPERIMENT SUPPORT
IN

- | INTEGRAL | ATTACHED | DETACHED |
|-------------|-------------------|----------|
| FLOOR SPACE | STORAGE SPACE | |
| LOGISTICS | UTILITIES/SERVICE | |
| OPERATING | SERVICE | |
| OPERATING | SERVICE | |
| OPERATING | SERVICE | |
- STRUCTURES
 - DOCKING
 - ELECTRICAL POWER
 - CREW SUPPORT
 - ENVIRONMENTAL CONTROL
 - LIFE SUPPORT
 - GUIDANCE AND CONTROL
 - INFORMATION MANAGEMENT

POINTING & STABILITY	EPHEMERIS
HARD LINE LINK	RF LINK

- MAJOR GUIDELINE

... TO EXTENT F. CRITICAL, EXPERIMENTS WILL BE ACCOMMODATED
WITHIN GENERAL PURPOSE LABORATORIES OR IN ATTACHED MODULES



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North American Rockwell

GENERAL ELECTRIC
SPACE DIVISION



NR has emphasized identifying standard experiment provisions as a major element of the general purpose laboratories. Shown here are the FPE's which drove the capabilities sizing for each of the major Space Station systems. It should be noted that some of the drivers are integral (5.13), some attached (5.24a, 5.11), and some detached (5.8). In almost every case, there is an FPE which is close in second place.

STATION EXPERIMENT PROVISIONS SUBSYSTEM (CONT)

50PDS104155A

● STATION SYSTEMS SIZING DRIVERS

SYSTEM	REQUIREMENT	DRIVING FPE
ELECTRICAL POWER	5280 WATTS	5.24a - MANNED SPACE FLIGHT ENGINEERING & OPERATIONS (HANGAR)
FLOOR SPACE	320 FT ²	5.13 - BIOMEDICAL & BEHAVIORAL RESEARCH
GUIDANCE & CONTROL	±0.25 DEG LOS STABILITY	5.11 - EARTH SURVEYS
CREW	5100 MAN-HRS (PER 180 DAYS)	5.13 - BIOMEDICAL & BEHAVIORAL RESEARCH
INFORMATION (DATA)	94×10^9 BITS PER DAY	5.11 EARTH SURVEYS
LOGISTICS	2200 LBS PER MONTH	5.8 COSMIC RAY PHYSIC
ENVIRONMENT CONTROL	18,000 BTU PER HOUR	5.24a - MANNED SPACE FLIGHT ENGINEERING & OPERATIONS (HANGAR)



SPACE DIVISION
GENERAL ELECTRIC

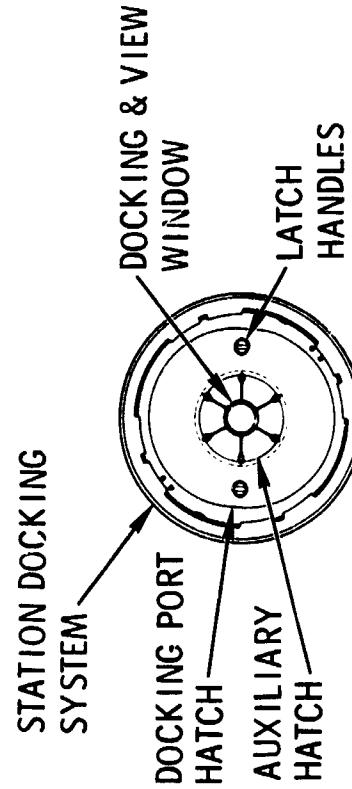


The standardized docking interface is provided at each of the docking ports for use by the attached or detached experiment modules. A standard interface with electrical power, environmental control/life support, and information management is provided. Any three of the docking ports can be utilized for supporting attached or detached experiment modules.

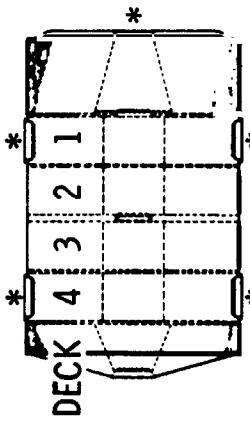
STATION EXPERIMENT PROVISIONS SUBSYSTEM (CONT)

50PDS104156

- DOCKING
 - SPACE STATION DOCKING PORT

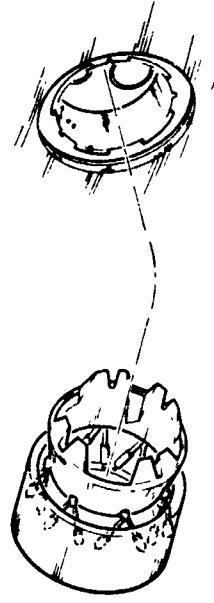


- DOCKING PORT LOCATIONS

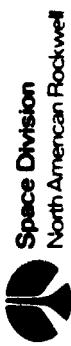


* NOTE
ANY 3 PORTS
MAY BE UTILIZED
FOR EXPERIMENTS

- NEUTER DOCKING SYSTEM



MODULE
DOCKING SYSTEM
STATION
DOCKING SYSTEM



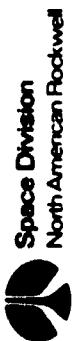
Next is presented a brief summary of some of the features of a typical attached experiment module from the point of view of its ability to support particular experiments and from the point of view of its interface with the core module. The earth survey module is shown here with an overall dimension of 15 ft diameter by 21 ft long.

EARTH SURVEYS MODULE EXPERIMENT PROVISIONS

MODULE EXPERIMENT PROVISIONS
SUBSYSTEMS (XPS) PROVIDES EXPERIMENT
SUPPORT IN

- STRUCTURES
 - DOCKING
 - ELECTRICAL POWER
 - CREW SUPPORT
 - ENVIRONMENT CONTROL - LIFE SUPPORT
 - ATTITUDE CONTROL
 - LOGISTICS
 - DATA ACQUISITION ASSEMBLY
-
- The diagram illustrates the Earth Surveys Module. It features a cylindrical central body with a circular hatch at the top. A rectangular sensor unit is mounted on the side of the module. Two dimensions are indicated: the diameter of the module is labeled as 14 FT DIA, and the distance from the center of the module to the tip of the sensor unit is labeled as 44.7 FT. An arrow points from the text 'TYPICAL EARTH SURVEYS SENSORS' to the sensor unit. Another arrow points from the text '21.0 FT' to the distance between the module's center and the sensor unit's tip.

SOME PROVISIONS ARE DIRECTLY OR
INDIRECTLY SUPPLIED BY THE
SPACE STATION



The sensor support requirements that have to be provided by the earth resources module to the sensors are indicated here. These are summarized from the Space Station experiment book, FPE 5.11, Earth Survey.

FPE 5.11 EARTH SURVEYS

50PDS104420

• SUPPORT REQUIREMENTS (SENSORS ON MODULE)

- SENSOR WEIGHT 3950 POUNDS TOTAL
- SENSOR VOLUME 445 CUBIC FEET
- POINTING + 0.25° @ 0.05° / SEC FOR 65 MINUTES
PER CYCLE AT LOCAL VERTICAL
- VIEWING AREA REQUIRED 440 SQUARE FEET
- FIELD OF VIEW + 80° IN-TRACK
- 75° CROSS-TRACK
- SENSOR POWER 4284 WATTS MAXIMUM SUSTAINED
- DATA ACQUISITION DIGITAL - 20.2 × 10⁶ BITS/SEC MAX
.94 × 10¹¹ BITS/DAY MAX
- CREW SUPPORT PHYSICAL - 635 #/MO
- CREW SUPPORT 9 MH/DAY - EXPERIMENT OPERATION



The overall weight of such an earth resources module is approximately 12,500 lb, and a gross breakdown between the experiments (approximately 4,000 lb), the structure (approximately 4,500 lb) and the other elements which make up the module are shown.

EARTH SURVEYS MODULE CONCEPT

WEIGHT SUMMARY

• ELECTRICAL POWER DISTRIBUTION	650 POUNDS
• SENSOR ATTITUDE CONTROL	1,600 POUNDS
• ENVIRONMENT CONTROL	150 POUNDS
• DOCKING SYSTEM	650 POUNDS
• INFORMATION MANAGEMENT	190 POUNDS
• ENVIRONMENTAL PROTECTION	830 POUNDS
• STRUCTURE	4,550 POUNDS
SUB TOTAL	8,620 POUNDS
EXPERIMENTS	3,950 POUNDS
TOTAL	<hr/> 12,570 POUNDS



This chart depicts the interface requirements between the earth surveys module and the Space Station in terms of electrical power, atmospheric control, closed loop cooling and information management together with a summary of the magnitudes of each one of these parameters available for all experiment support by the core module.

EARTH SURVEYS MODULE/SPACE STATION INTERFACE

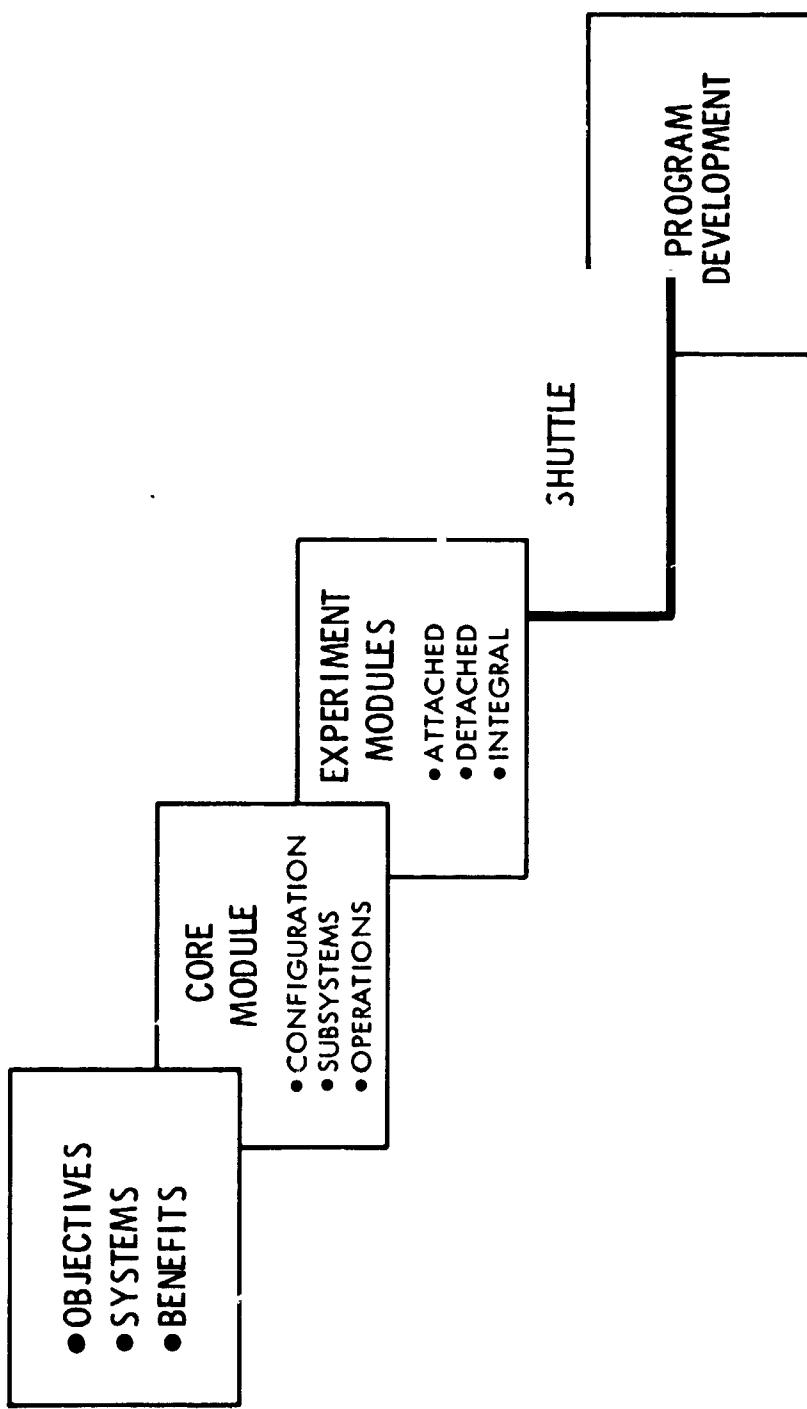
UTILITY	QUANTITY AVAILABLE FOR ALL EXPERIMENTS	QUANTITY CURRENTLY REQUIRED BY EARTH SURVEYS MODULE
ELECTRICAL POWER		
	6 KW AVERAGE	1.3 KW AVERAGE
	9 KW MAXIMUM	5.1 KW MAXIMUM
	10 KW PEAK	6.5 KW PEAK
ATMOSPHERE CONTROL		
	3415 BTU/HOUR PLUS HUMIDITY & CO ₂ REMOVAL FOR FIVE MEN	1740 BTU/HOUR PLUS HUMIDITY & CO ₂ REMOVAL FOR TWO MEN
CLOSED-LOOP COOLING		
	20,490 BTU/HOUR	NONE
INFORMATION MANAGEMENT		
	10 X 10 ⁶ BITS/SEC MAX	1.1 X 10 ⁶ BITS/SEC MAX
	158 X 10 ⁹ BITS/DAY MAX	94 X 10 ⁹ BITS/DAY MAX
	4.5 MEGA Hz TV	4.5 MEGA Hz TV



Space Division
Rockwell International

50PDS104422

PRESENTATION OUTLINE



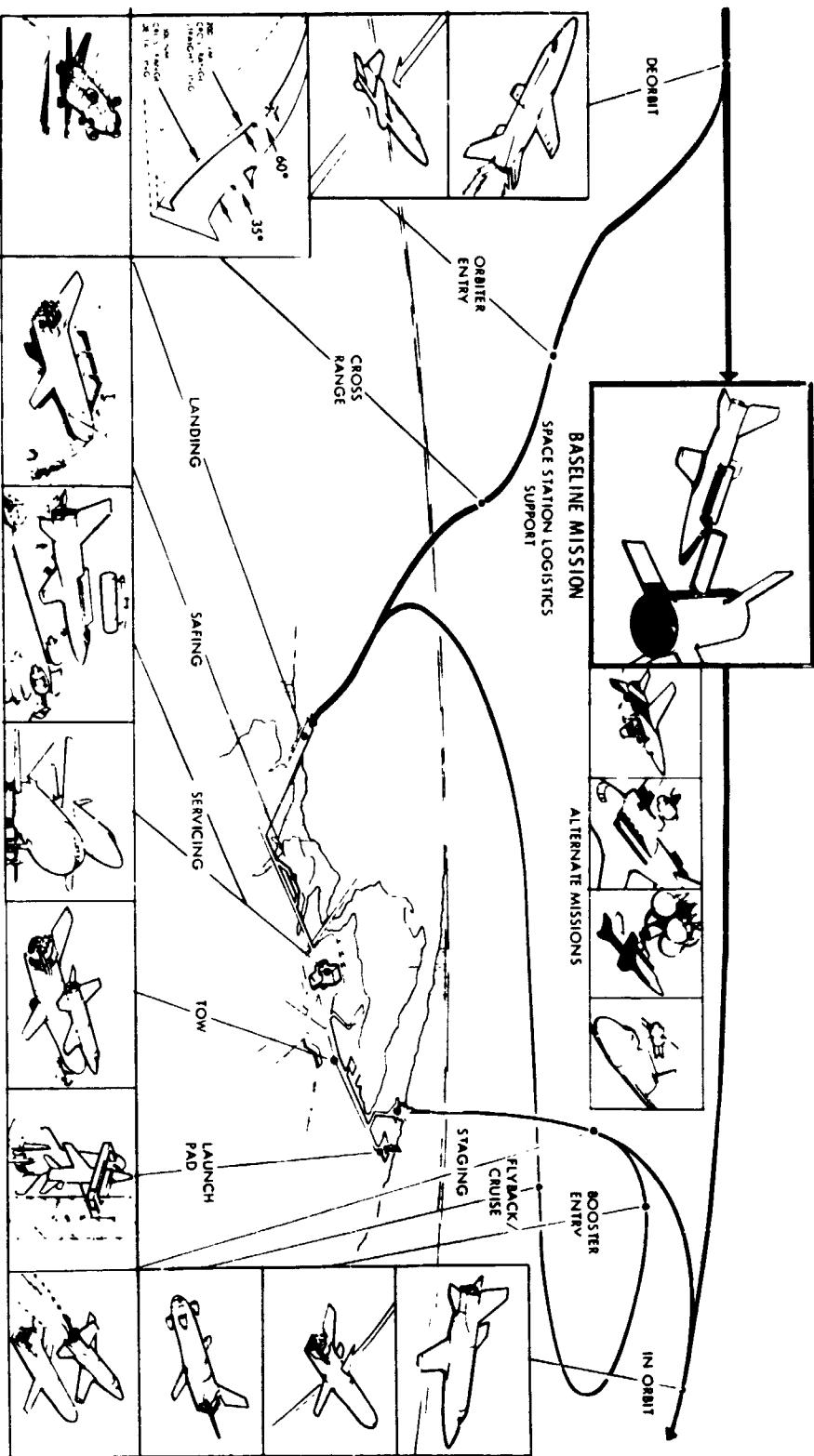
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50PDS104430



This presentation will digress from the Space Station Phase E Study to provide an overview of the Space Shuttle with particular reference on the way that it interfaces and supports the Space Station. This figure shows the overall Space Shuttle mission profile from liftoff through boost and orbit injection. It then indicates the Space Station logistics support as being the baseline mission for design of the Shuttle, but in addition there is a wide range of ultimate missions which the Shuttle can support not involving the Space Station. Typical of these ultimate missions is the deployment and perhaps subsequent retrieval and return to earth of an unmanned experiment module. The Shuttle mission profile then shows the sequence of events from deorbit through landing and the subsequent ground operations necessary to prepare the Shuttle again for launch to support the next mission.

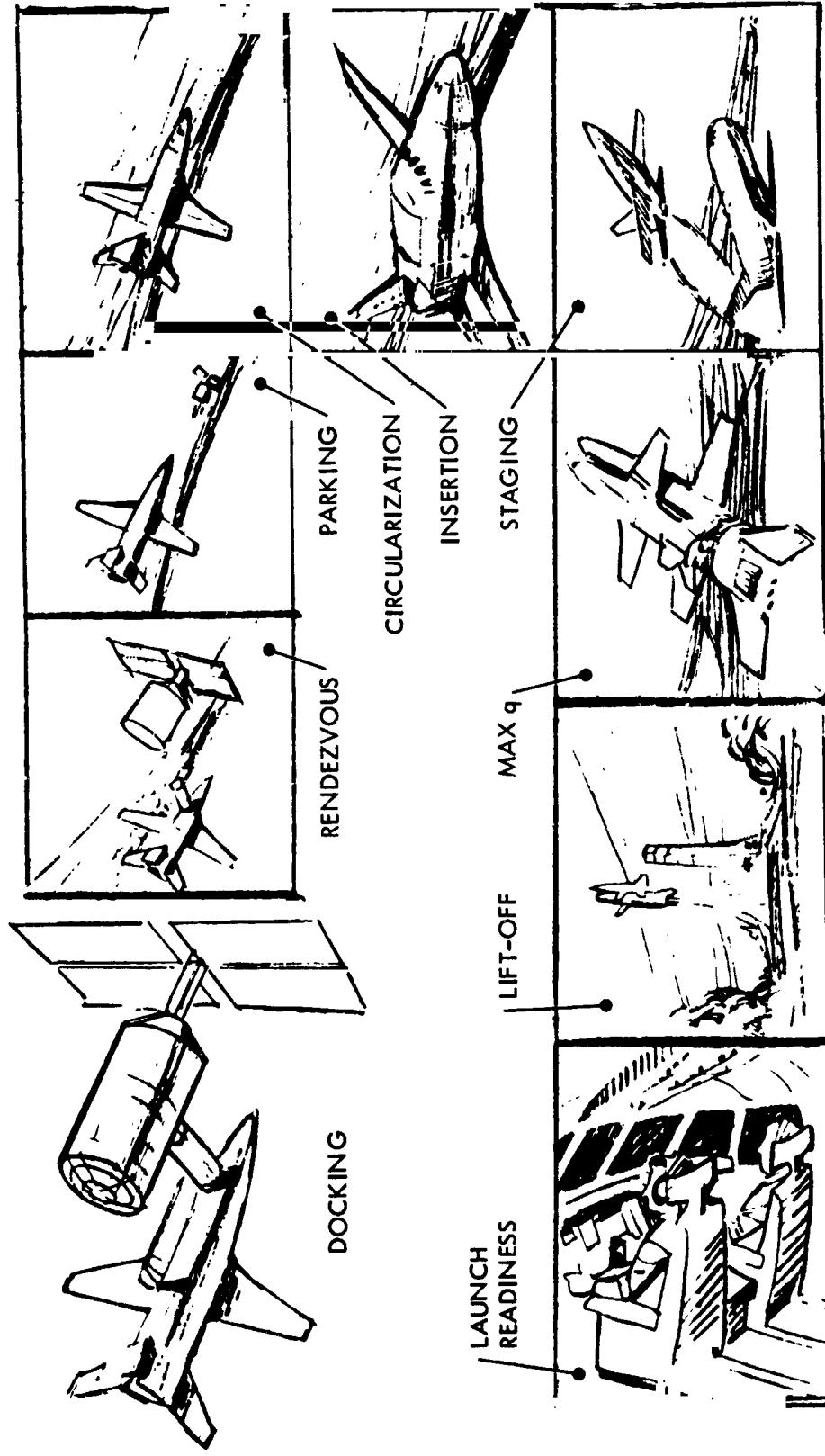
SHUTTLE MISSION PROFILE





Presenting a more detailed look at the mission events from launch to docking, this chart depicts the launch readiness preparation through the max q and the subsequent staging operations, the insertion into the 50 by 100 nautical-mile elliptical orbit, and the subsequent rendezvous and docking maneuvering.

MISSION EVENTS - LAUNCH TO DOCKING



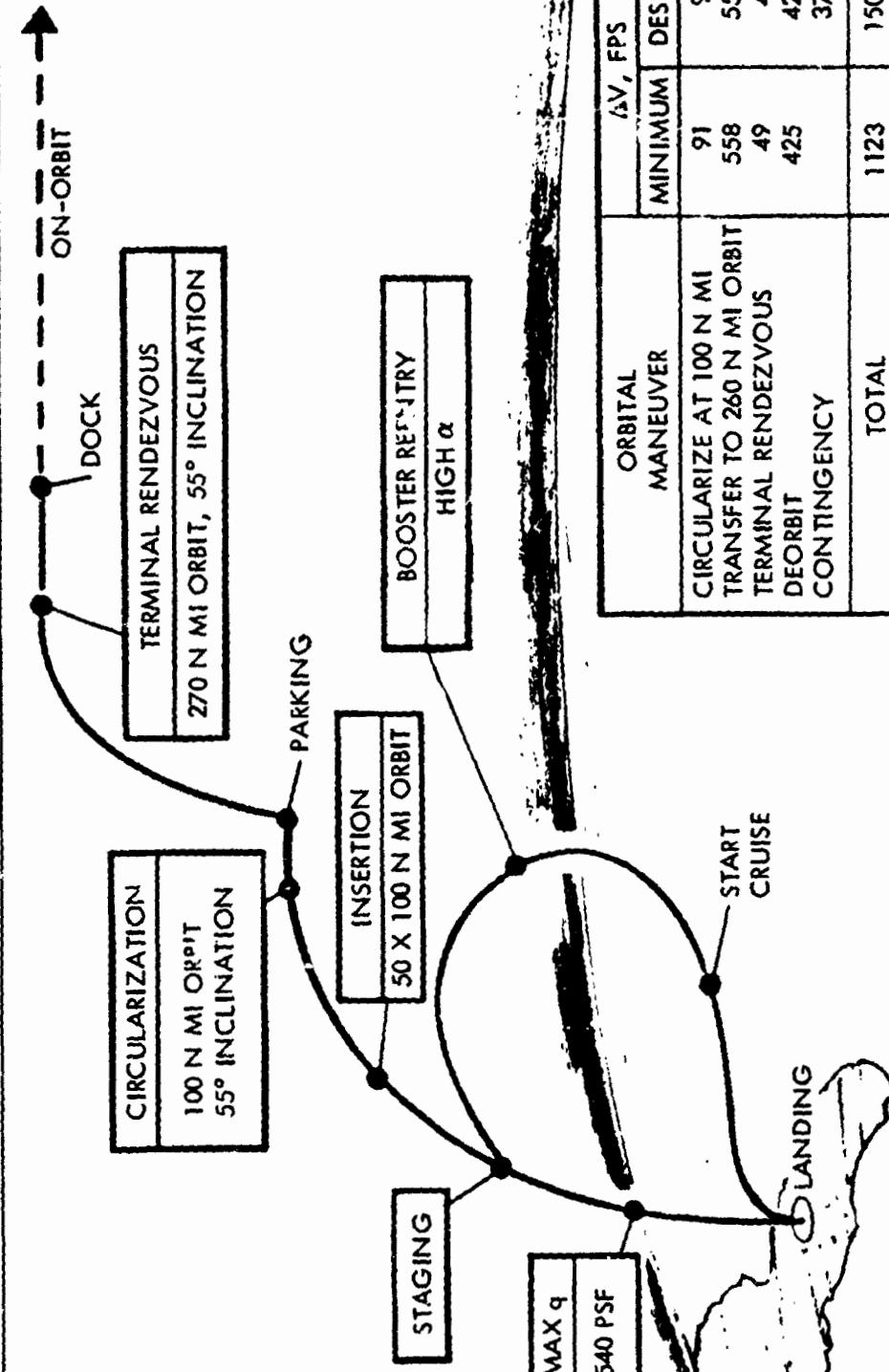
Space Division
North America Rockwell

505V2866



A flight profile for the ascent phase of the mission indicates a maximum dynamic pressure of approximately 540 lb per square foot, the insertion into the 50 by 100 nautical-mile orbit with a circularization maneuver at the 100 nautical-mile apogee, and a subsequent Hohmann transfer into the 270 nautical-mile 55-degree orbit of the Space Station. The insert indicates the range of ΔV in feet per second associated with these orbital maneuvers.

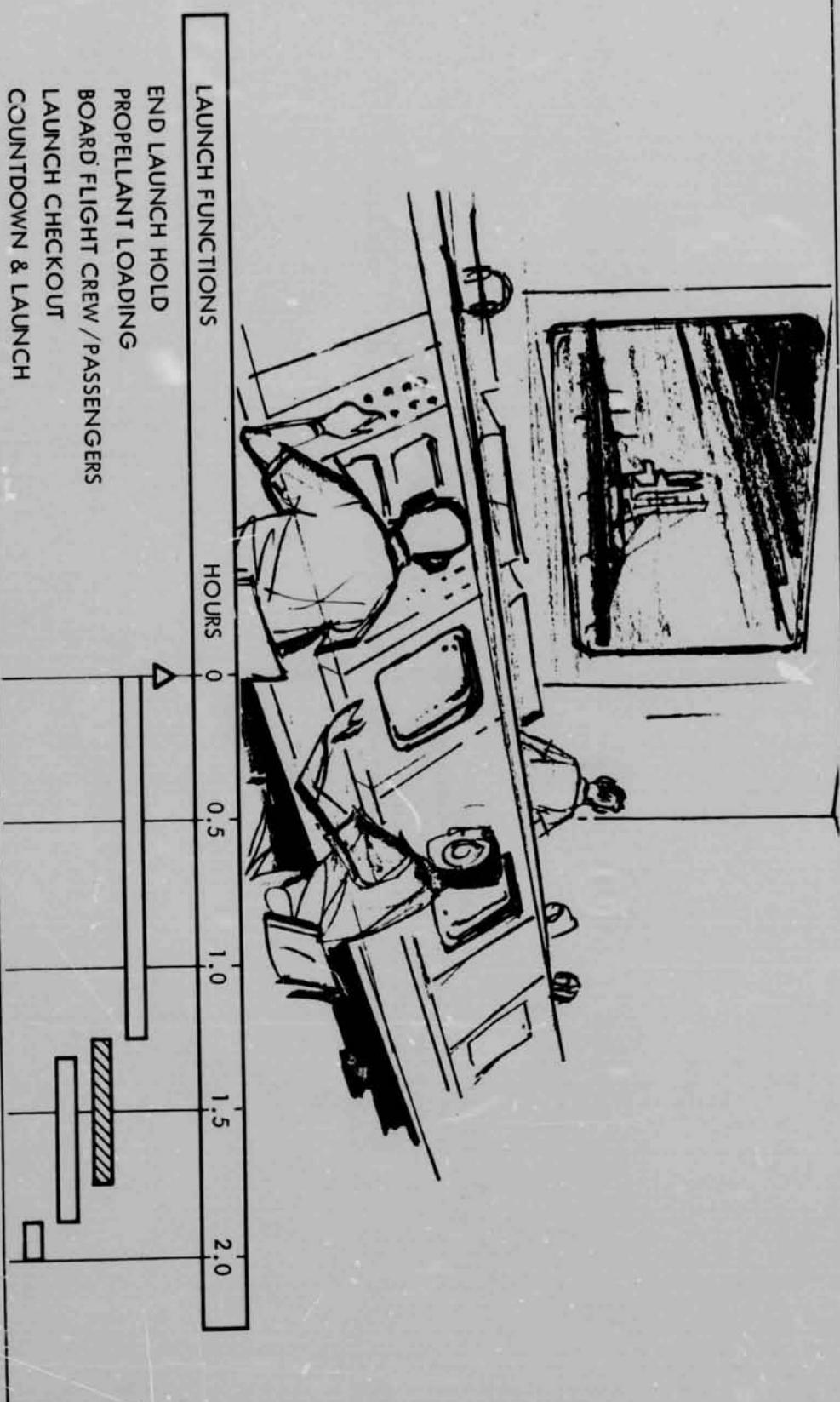
BOOST FLIGHT PROFILE





One of the major features of the Shuttle is that it will offer very flexible, convenient, and short response means in transportation from earth to orbit. The Shuttle will be designed such that during the last two hours prior to launch the propellant can be loaded, the flight crew and passengers boarded, the final launch checkout accomplished using the onboard checkout system, and then the final countdown and launch accomplished.

T-MINUS 2 HOURS



505V2868A

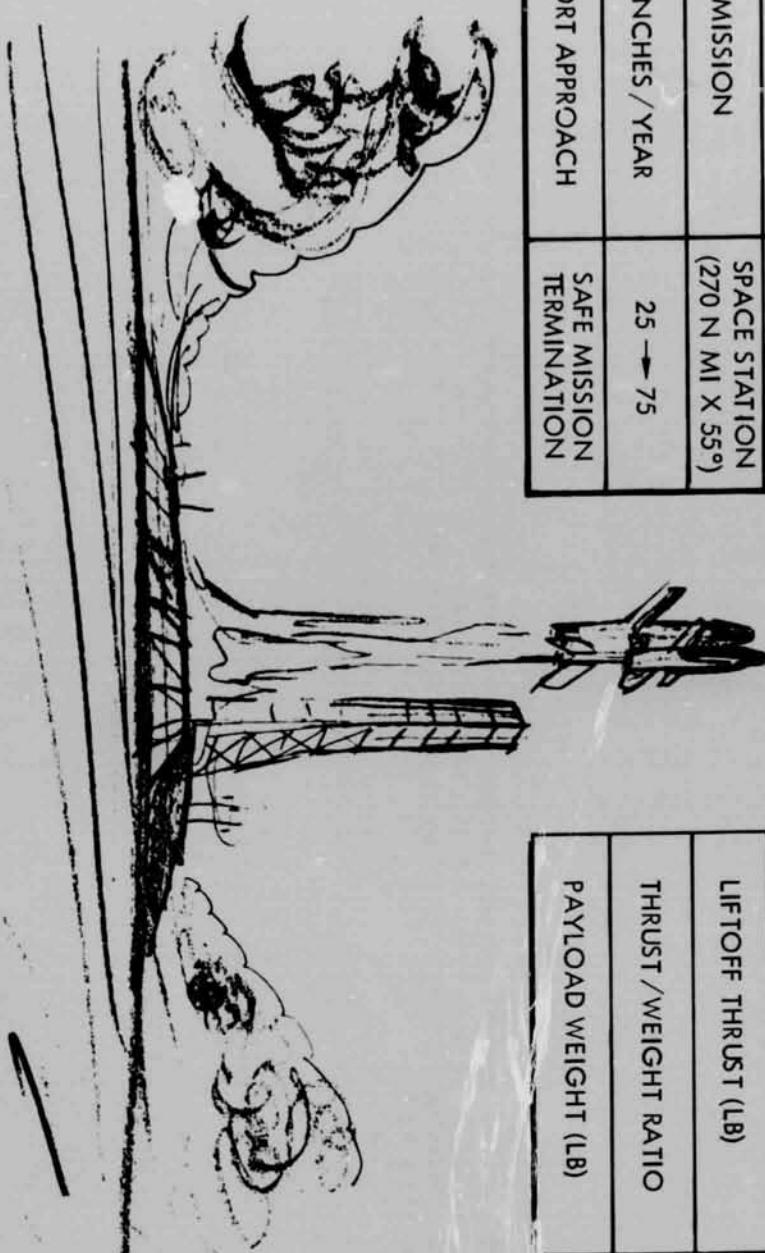


At liftoff the Shuttle will weight 3.5M pounds "all up". Of this, the orbiter will weigh 760,000 pounds and the booster 2,740,000 pounds. The liftoff thrust is close to 5M pounds giving a thrust to weight ratio of 1.37. The payload that such a vehicle can transport into orbit is up to 40,000 pounds. It is anticipated that in the decade of the 80's, in the range of 25 to 75 flights per year might be made with the Shuttle vehicle.

LIFT-OFF

LAUNCH SITE	KSC
NUMBER OF PAD	2
REF MISSION	SPACE STATION (270 N MI X 55°)
LAUNCHES / YEAR	25 → 75
ABORT APPROACH	SAFE MISSION TERMINATION

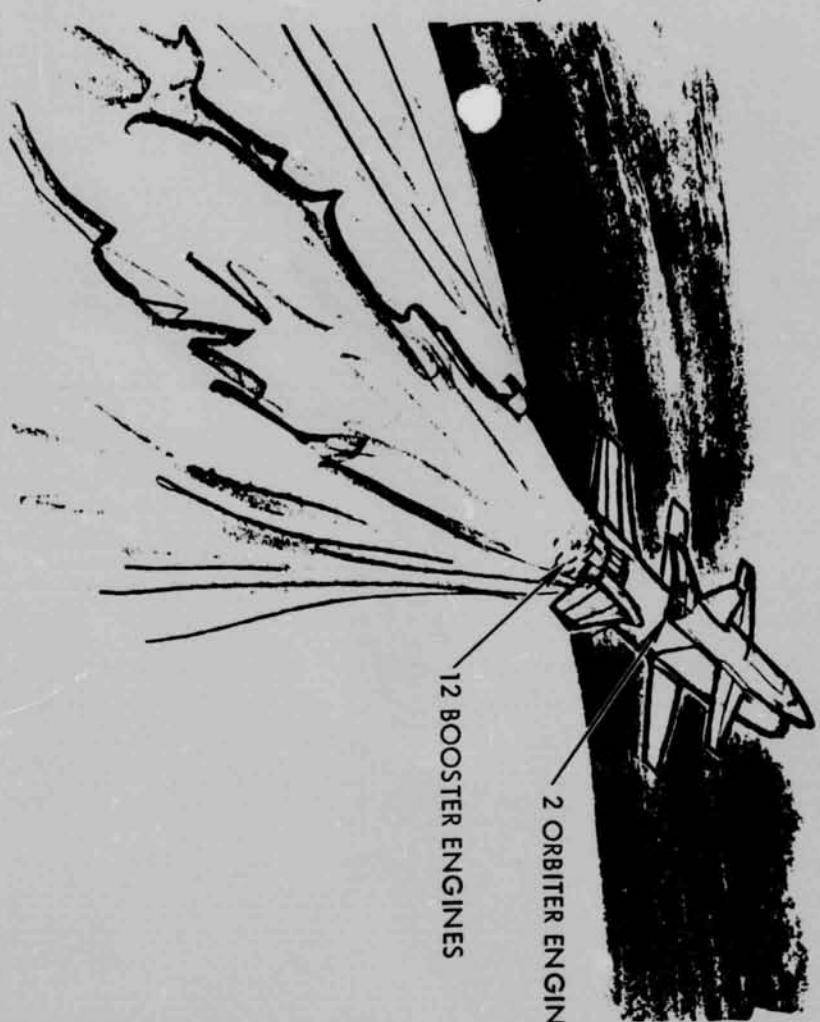
GROSS LIFTOFF WEIGHT (LB)	3,500,000
ORBITER WEIGHT (LB) BOOSTER WEIGHT (LB)	760,000 2,740,000
LIFTOFF THRUST (LB)	4,800,000
THRUST / WEIGHT RATIO	1.37
PAYOUT WEIGHT (LB)	40,000





The maximum dynamic pressure of approximately 550 pounds per square foot will be achieved 65 seconds after liftoff, at an altitude of 32,000 feet. The maximum acceleration just prior to first stage separation that will be felt by the crew will be 3 g's.

BOOST FLIGHT



MAX DYNAMIC PRESS = 550 PSF

TIME = 65 SEC

VELOCITY = 1100 FPS

ALTITUDE = 32,000 FT

2 ORBITER ENGINES

12 BOOSTER ENGINES



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505V2873A



At approximately 190 seconds after liftoff, at a velocity of 9,400 feet per second and at an altitude of 215,000 feet, the orbiter will separate from the booster. The booster will then reenter through the atmosphere and fly back to a landing site adjacent to a launch site.

STAGING & SEPARATION



TIME = 189 SEC
VELOCITY = 9400 FPS
ALTITUDE = 215,000 FT

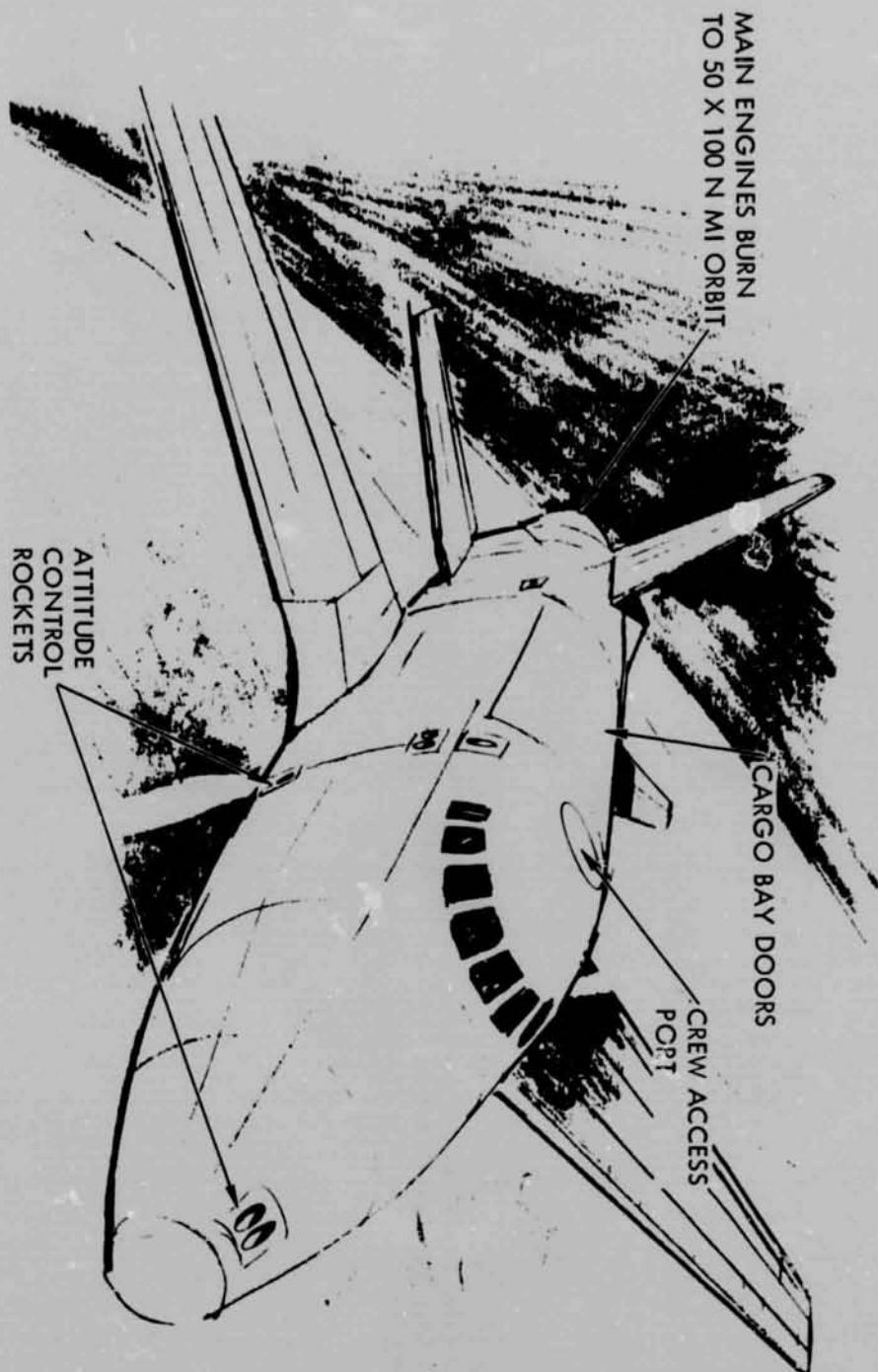

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50SV2874



The initial orbit of 50 by 100 nautical miles is achieved using the orbiter main engines. Once outside the atmosphere, suitably placed attitude control rockets are used for vehicle stabilization.

ORBIT ATTAINMENT



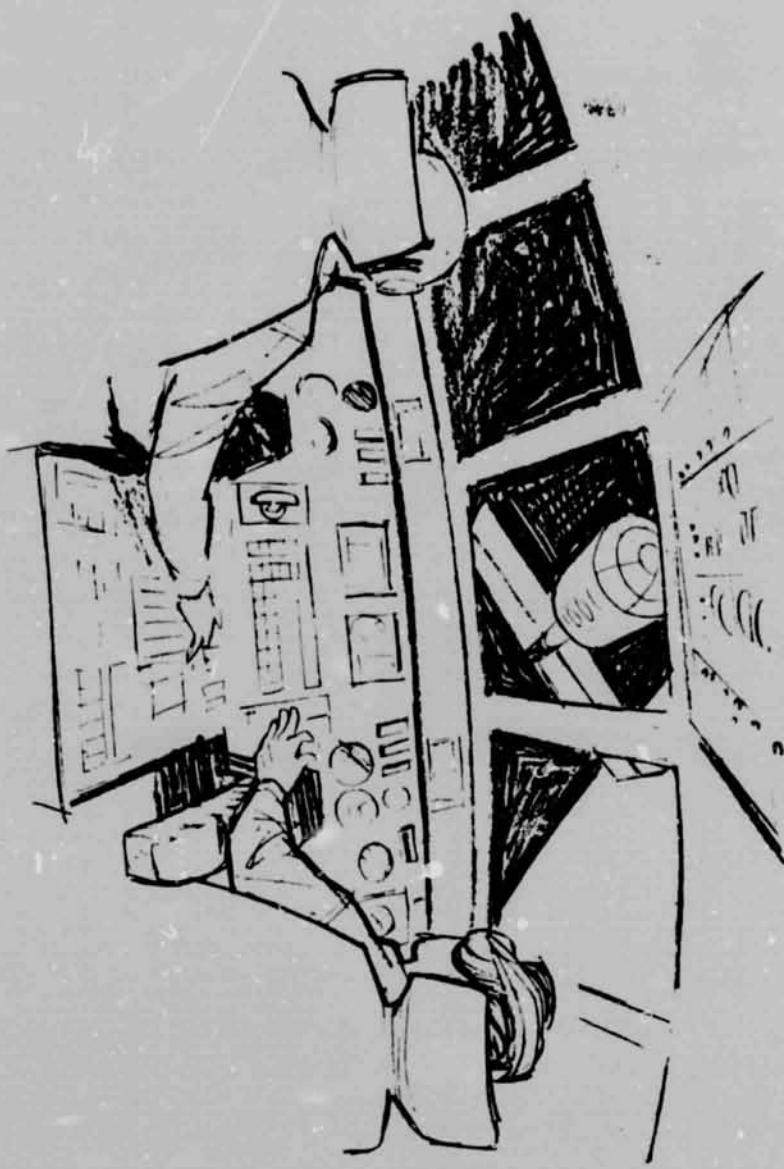
 Space Division
North American Rockwell

50SV2875



This figure shows the view from the crew compartment while the orbiter is approaching the Space Station.

FINAL DOCKING



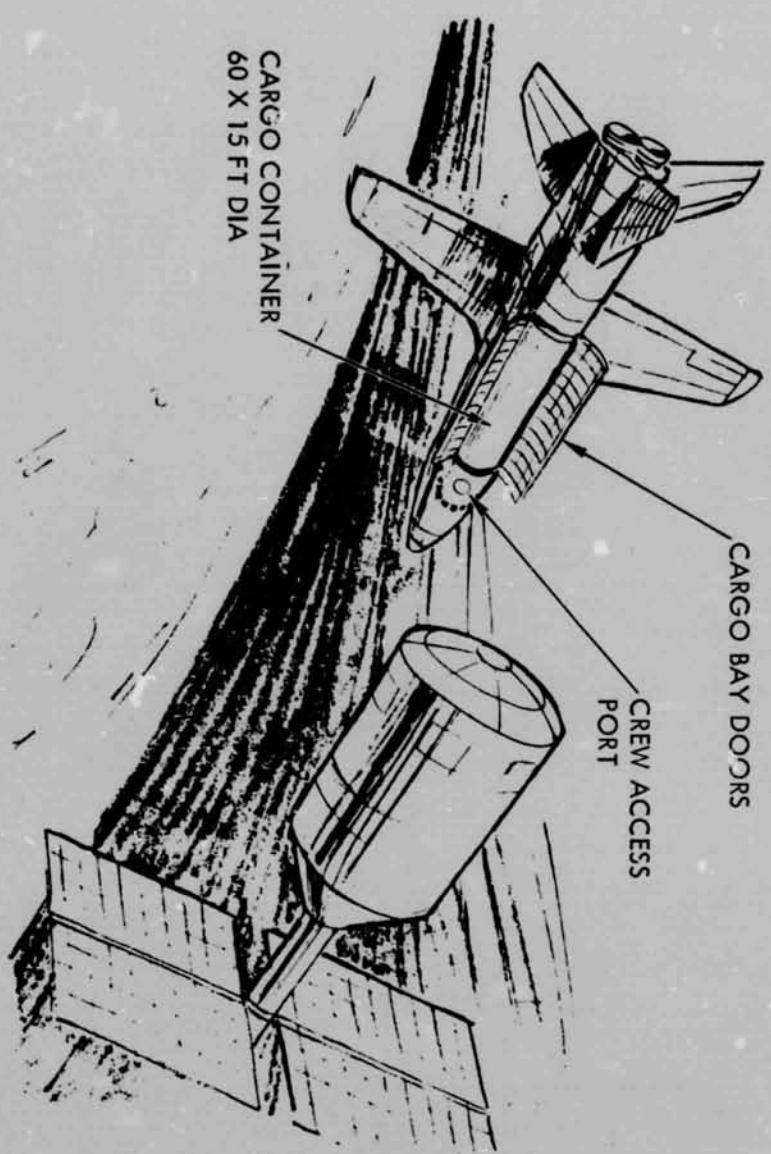
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North American Rockwell

50SV2881



Following initial rendezvous with the Space Station, the 60-foot-long cargo bay doors on the upper side of the orbiter will open to expose the 60-foot-long by 15-foot-diameter cargo module.

DOCKING ALIGNMENT



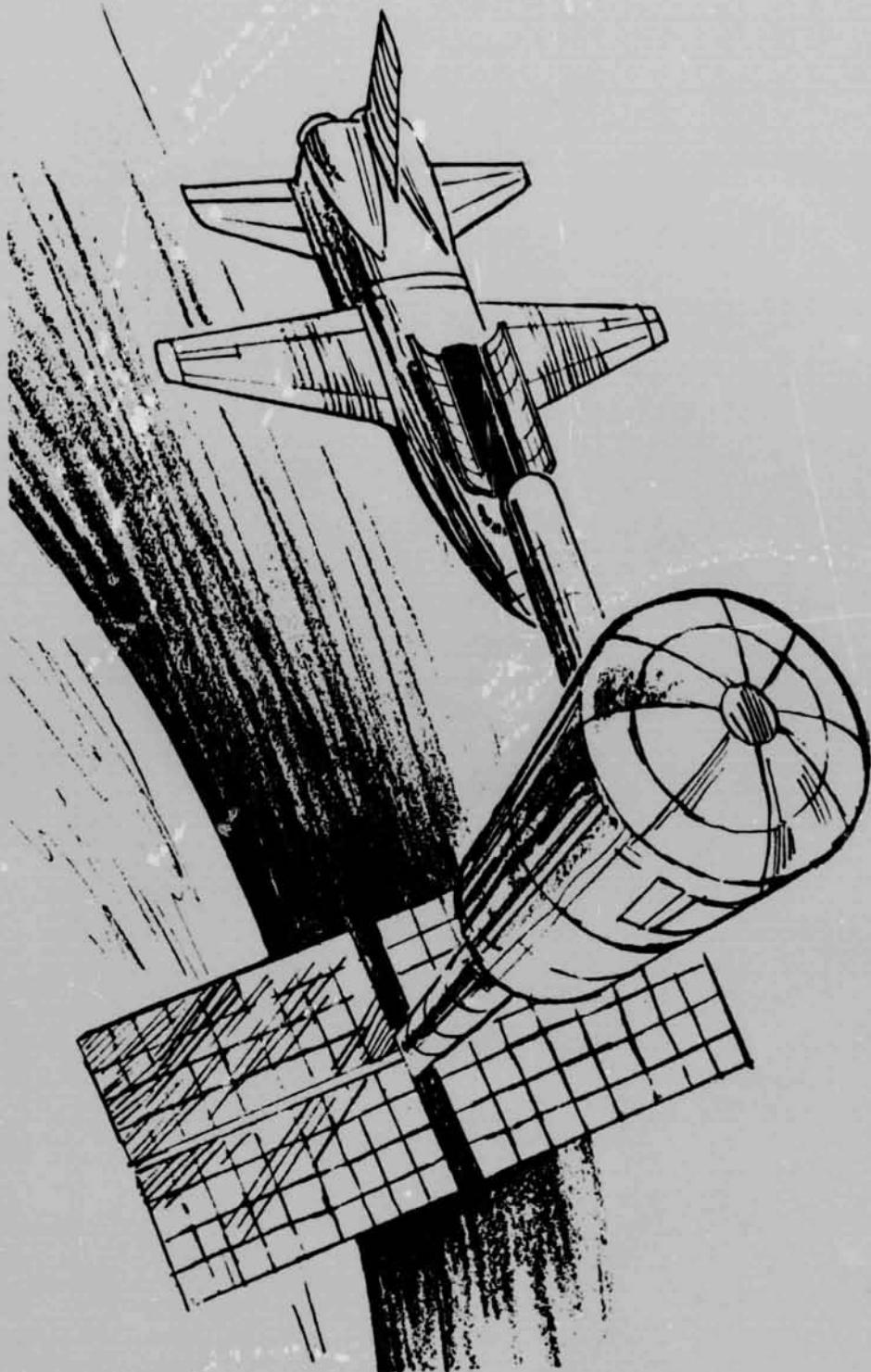
 **Space Division**
North American Rockwell

50SV2878



This shows the Shuttle/cargo module docked to the Space Station for crew and cargo transfer.

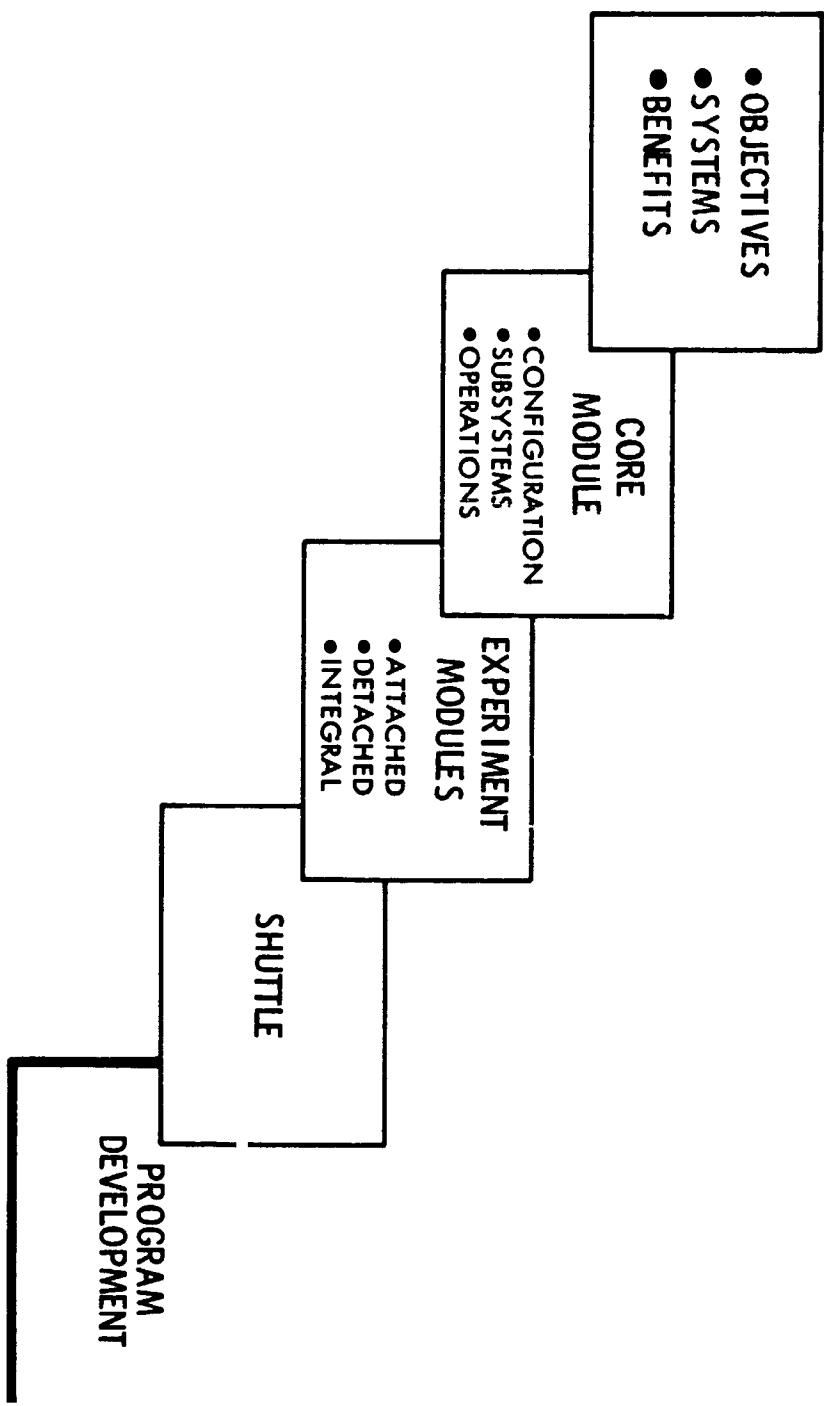
CARGO TRANSFER



 Space Division
North American Rockwell

50SV2882A

PRESENTATION OUTLINE

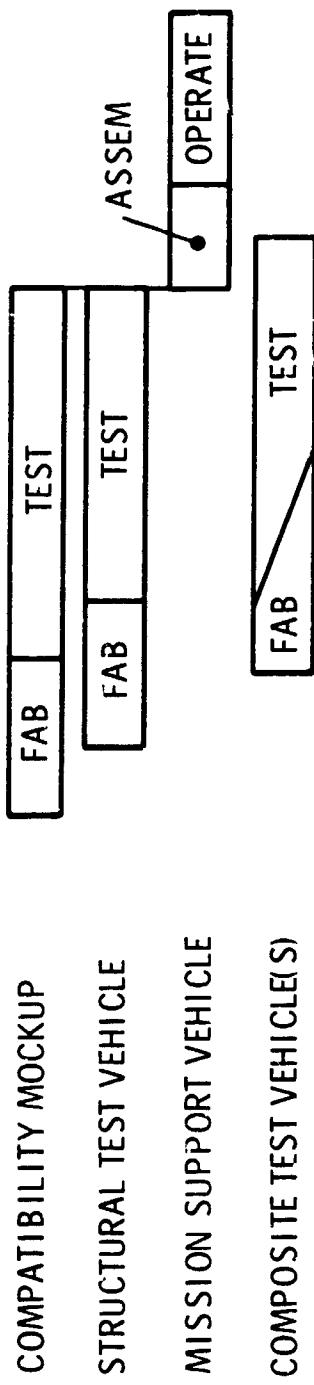


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Next is given a brief description of the type of development test program that is foreseen prior to the launch of the Space Station into orbit. In addition to a large range of component- and assembly-level development and qualification type testing, it is foreseen that several major test units will be required. A sophisticated compatibility mockup using operable subsystems and a structural test vehicle will be required. Following launch of the Space Station, the flight-type elements from the compatibility mockup will be installed in the major structural test vehicle to make a mission support vehicle which will be used to undertake tests and simulations while the Space Station is operating in earth orbit. In addition, a number of partial vehicles equating to approximately two total Space Station core modules is envisaged.

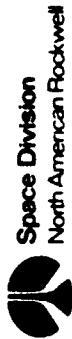
MAJOR TEST HARDWARE IDENTIFIED TO DATE



△
LAUNCH
INITIAL
SPACE STATION

* NOTE:

COMPOSITE TEST VEHICLE EQUATES TO APPROX 2 VEHICLES
AT PRESENT TIME



The compatibility mockup is a major development and integration tool. It will represent a four-story building with each deck layed out on each one of the floors of the building and with provisions for Space Station utility runs being provided. Supporting bench maintenance-type laboratories will be adjacent to this mockup. Initially Space Station prototype subsystems, later to be replaced with flight-rated subsystems, will be used and a representative secondary structure/mounting provisions and block-box interconnections will be used. This major test article for the core module will be located at the prime contractor's facility. One of the major objectives of the compatibility mockup is to assure the integration and compatibility of the onboard checkout system with the Space Station subsystems that it is designed to check out.

MAJOR TEST ARTICLE SITES

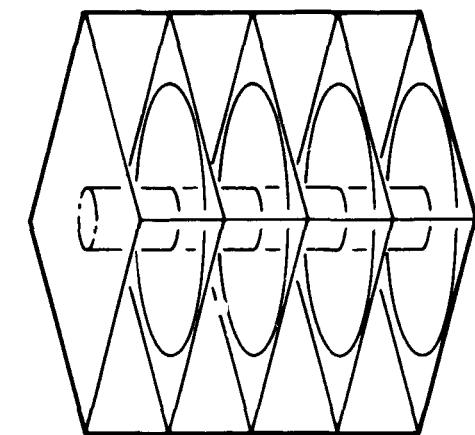
- COMPATIBILITY MOCKUP (INTEGRATION LABORATORY)

4 STORY BLDG

SPACE STATION DECK
LAID OUT IN EACH
FLOOR

PROVISIONS FOR SS
UTILITY RUNS &
ACCESS

ENVIRONMENTAL CONTROL
BENCH MAINT. LABS
AVAILABLE



SPACE STATION
SUB-SYSTEMS*

INTERCONNECTIONS

SECONDARY STRUCTURE

MOUNTING PROVISIONS

*MAY BE PROTOTYPE INITIALLY
LATER REPLACED WITH FLIGHT
RATED

AT PRIME CONTRACTOR'S FACILITY

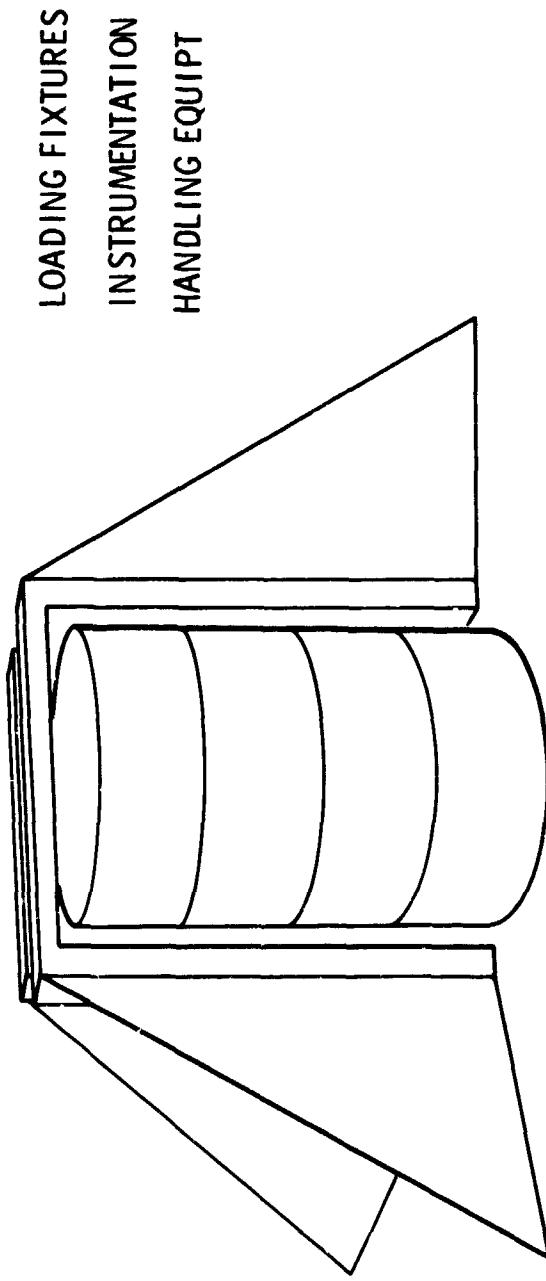


A major structural test vehicle with complete primary structure and secondary structure as required, together with the appropriate loading fixtures and instrumentation, will be necessary.

MAJOR TEST ARTICLE SITES (CONT)

STRUCTURAL TEST VEHICLE

- COMPLETE PRIMARY STRUCTURE
- SECONDARY STRUCT AS REQUIRED



AT PRIME CONTRACTORS MFG FAC

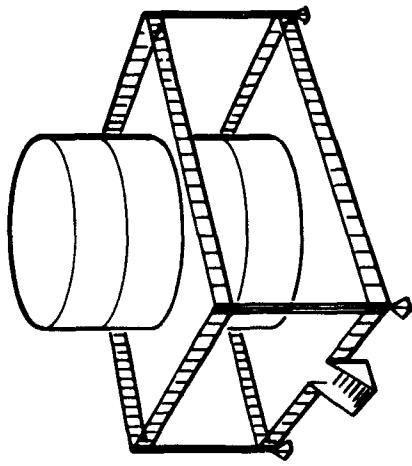
50PDS104181

One of the primary purposes of the mission support vehicle is to demonstrate the compatibility of modules, such as an earth-resources attached module, which will be launched after the launch of the initial Space Station core module. As a result, it is necessary to maintain rigorous flight hardware type configuration management. This mission support vehicle should probably be located near the Shuttle launch site.

MAJOR TEST ARTICLE SITES (CONT)

- MISSION SUPPORT VEHICLE

COMPLETE SPACE STATION CORE MODULE

- 
- The diagram shows a cylindrical core module with various equipment attached. Labels indicate:
- INSTRUMENTATION (GROUND STA)
 - HARDWIRE & RF
 - HIGH BAY AREA
 - ACCESS STANDS
 - HANDLING &
 - SERVICE POWER
 - BENCH MAINT AREAS
 - ACCESS FOR INSTL OF ATTACHED MODULES

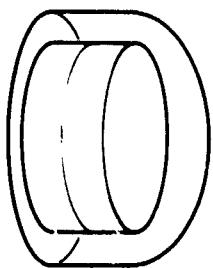
SHOULD BE LOCATED NEAR
ALS LAUNCH SITE



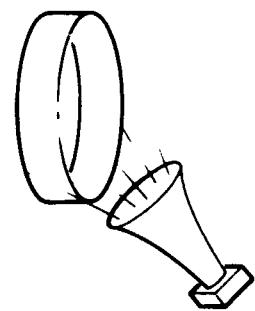
In addition to the previously discussed major test articles, partial systems test articles used for thermal vacuum testing, acoustic testing, dynamic testing, and other tests such as docking are foreseen.

MAJOR TEST ARTICLE SITES (CONT)

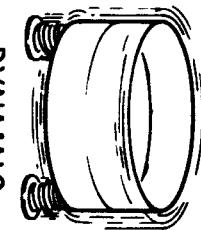
COMPOSITE TEST VEHICLES(S)



THERMO VAC



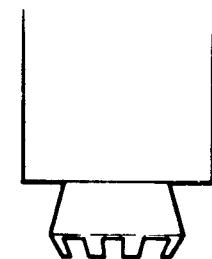
ACOUSTIC



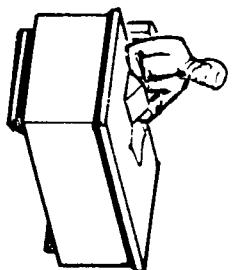
DYNAMIC

MAJOR SECTIONS AT MSC

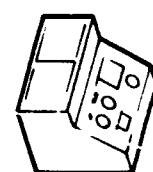
OTHER AT PRIME OR MSC AS APPLICABLE



DOCKING SECTIONS



SIMULATORS



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50PDS104183A

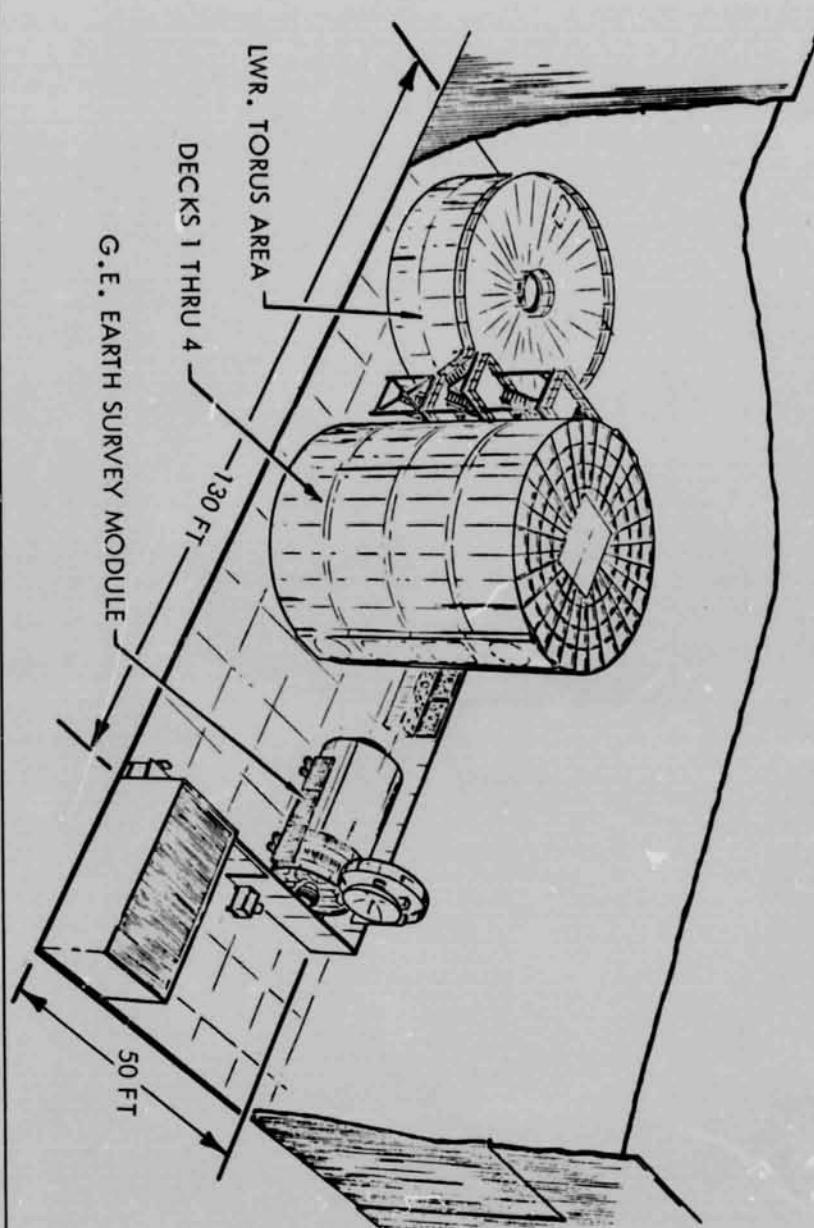


One of the objectives of the current Phase-B contract is to construct a full-scale mockup, a 33-foot-diameter core module; and a 14-foot-diameter earth survey module. These mockups shown currently in an advanced state of construction, will be located at Seal Beach, California, for mockup reviews and demonstrations.

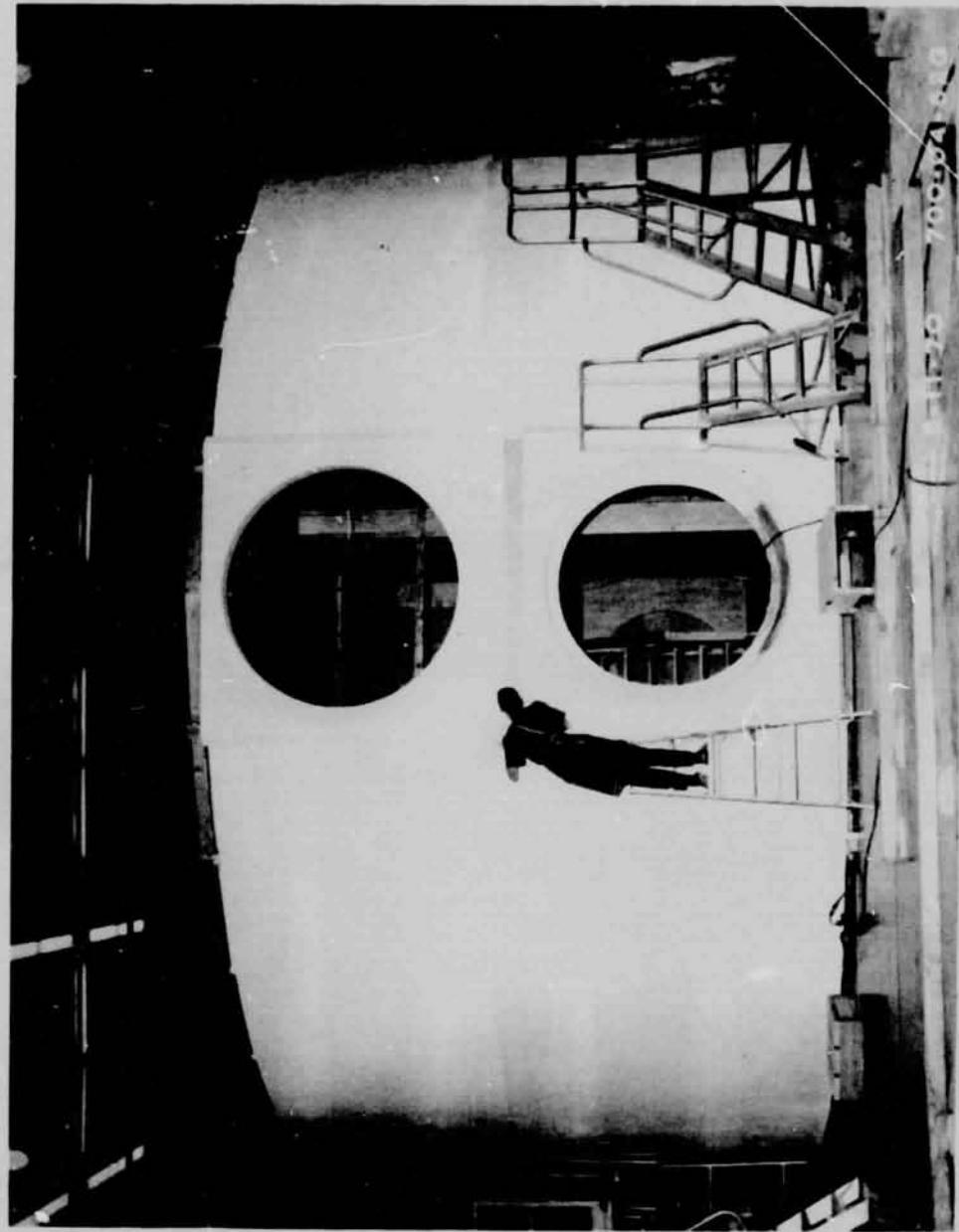
MOCK-UP PLANS

NR DISPLAY AREA

NORTH AMERICAN ROCKWELL
SPACE DIVISION
SEAL BEACH FACILITY
BUILDING S-14



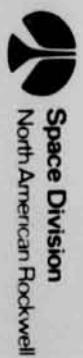
CORE MODULE MOCKUP



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50PDS104434



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CORE MODULE MOCKUP

5OPDS104433



As mentioned earlier, NR is rapidly approaching the completion of the Space Station Phase-B program definition activity. This will be completed on July 31, 1970. Following this some further activity will be conducted to penetrate some of the open issues such as the electrical power subsystems selection. The Phase-C detailed design activity for the Space Station might occur during calendar 1972, with the Phase-D development following one year later. This program would be compatible with a Space Station core module launch in the third quarter of 1977.

SUMMARY

SPACE STATION IS VITAL ELEMENT OF EARTH ORBITAL PROGRAM

- SCIENCE
- APPLICATIONS
- STEPPINGSTONE TO FUTURE MISSIONS

SPACE STATION PHASE B DEFINITION APPROACHING COMPLETION

- CORE MODULE
- EXPERIMENT MODULES / SUPPORT PROVISIONS

SHUTTLE PROVIDES LOW COST, CONVENIENT CREW/LOGISTICS SUPPORT